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Reusing Cleaned Up Superfund Sites:

Golf Facilities Where Waste is Left on Site

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Golf Facilities Where Waste is Left on Site

Office of Superfund Remediation and Technology Innovation
Office of Solid Waste and Emergency Response
U.S. Environmental Protection Agency
Washington, DC

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Preface

As of August 2002, more than 300 cleaned up Superfund sites have been returned to productive use. Many of these sites have been developed into recreational facilities, such as sports fields, hiking trails, parks, playgrounds, and golf courses. Many other Superfund sites may potentially be used for similar purposes after they are cleaned up. The U.S. Environmental Protection Agency (EPA), through efforts such as the Superfund Redevelopment Program, promotes the productive reuse of Superfund sites. EPA's overriding objective for any Superfund site is to ensure protection of human health and the environment. With forethought and effective planning, communities can return sites to productive use without jeopardizing the effectiveness of the remedy put into place to protect human health and the environment.

This report provides technical information useful in planning, designing, and building golf facilities on sites where the remedy calls for on-site containment of contaminated material or post-construction monitoring or treatment. This information may be useful when considering golf facility reuse options during EPA's process of selecting, designing, and implementing a cleanup plan for a Superfund site or non-time-critical removal action. The report draws from experiences at completed redevelopment projects, EPA technical guidance, and other sources to describe remedy approaches and golf facility design features that have been used to accommodate golf courses at remediated Superfund sites where waste has been left on site.

This document is intended for information purposes only and does not create new or alter existing Agency policy or guidance. It is one of a series being developed under EPA's Superfund Redevelopment Program to inform stakeholders at hazardous waste sites about technical and planning issues that may arise during the remediation process when reuse of a site is intended following cleanup. Other reports in this series provide technical information on the reuse of Superfund sites with waste containment areas for recreational facilities, commercial and industrial facilities, and ecological resources.

This report was a collaborative effort between the U.S. Army Corps of Engineers, EPA, and an advisory committee headed by Paul Parker of The Center for Resource Management in Salt Lake City, Utah. The remainder of the advisory committee consisted of the following individuals: Ken Dixon of Texas Tech University, Ed Hopkins of the Sierra Club, Bill Love of W.R. Love Golf Course Architecture, John Olenoski of Nicklaus Design, Fred E. "Derf" Soller of Breckenridge Golf Club, and Paul Thomas of U.S. EPA Region 5.

Contents

Section 1. Introduction

Across the country, EPA is working with communities to safely return Superfund sites to productive use consistent with protection of human health and the environment. Former landfills, abandoned hazardous waste dumps, and other contaminated properties throughout the United States, once thought to be of limited or no value, are being transformed into viable commercial and industrial developments, parks and other recreational facilities, and wildlife areas. Golf courses and driving ranges have been built on a number of the more than 300 former Superfund sites that are in use. These golfing facilities provide positive social, economic, and environmental outcomes for their communities.

Remedies at some Superfund sites where wastes or treatment and monitoring systems remain on site after construction of the remedy reduce or control risks without completely eliminating them. Therefore, redevelopment planners must take into account the vital need to prevent long-term risks to human health and the environment by integrating into their plans any aspects of a remedy that are designed to monitor and maintain its effectiveness. Several sections of this report include information on design considerations, operation and maintenance (O&M) measures, and regulatory requirements vital to ensuring that remedies remain protective of human health and the environment.

EPA's experience suggests that sites where the cleanup involves containing the wastes on site are often well suited for recreational uses such as a golf facility. For example, the on-site containment of wastes often requires vegetated cover systems that, with minor modifications, can be made highly compatible with golf facility use.

This report provides techniques for ensuring that containment systems or waste treatment equipment can accommodate golf facilities, while ensuring that golf facility operations do not reduce the effectiveness of the remedy. The successful and safe use of a Superfund site for golf facilities requires careful planning, the involvement of the community and other interested parties, and appropriate design, construction, and post-construction operation and maintenance practices.

Purpose

This report was developed for site managers, communities, property owners, developers, golf course designers and operators, and others who might have an interest in building a golf course on a remediated Superfund site. It provides information useful for planning, designing and implementing site cleanups that will safely support golf facilities. The information could also be applied at certain non-time-critical removal sites. The report describes how redevelopment and remediation efforts can be coordinated to ensure successful golf facility projects at sites where some or all of the hazardous wastes will be, or have been, left on site. It focuses on the planning-level issues, not detailed design information. This document does not address how communities and property owners plan for the reuse of these cleaned up sites. It is generally their responsibility to decide how they will use these properties, although the remedy may limit some future uses.

The information in this document is based on the combined experiences of successful Superfund remediation and reuse projects, previous EPA technical guidance, and other sources. It includes considerations for determining whether or not a golf facility is appropriate for a site; remedy design, construction, and maintenance issues important for a site; and references to completed projects. This information may be useful in supporting remedy selection, design, construction, long-term monitoring and maintenance, and general reuse and community planning.

This report in no way alters established EPA policies on remedy selection for Superfund sites. The national program goal of the Superfund remedy selection process is to select remedies that are protective of human health and the environment, that maintain protection over time, and that minimize untreated waste left on site. (40 CFR 300.430). In many instances, Superfund remedies will include combinations of treatment for "principal threat wastes" (high concentration or mobile wastes), engineering controls to contain lower concentration wastes, and institutional controls (i.e., restrictions on the use of a property that may be implemented through legal or administrative mechanisms such as easements or deed notices) to supplement the engineering controls and minimize the potential of exposure to waste remaining on site.

This report is one of several being developed under the EPA Superfund Redevelopment Program to inform stakeholders at hazardous waste sites about how EPA may take identified and potential reuse into account when it selects, designs, and implements remedies. Other reports in this series address the reuse of sites for other kinds of recreational facilities, for commercial facilities, and as ecological resources.

Who Should Read the Report and Why

Many entities or stakeholders have a substantial interest in the redevelopment of a Superfund site. The **potentially responsible parties (PRPs) or the owner** could gain revenues from the operations of a golf facility. **Local governments** may benefit from increased tax revenues, and may need to consider whether the proposed facility is compatible with their land use plans. **Local citizen groups and individuals** may be concerned with employment and recreational opportunities and the character of their neighborhood. **Environmental organizations** might be consulted because the redevelopment project may provide the opportunity to protect or improve local and regional habitats. **EPA remedial project managers (RPMs)** and the **state regulators** need to coordinate remediation and reuse efforts at Superfund sites. **Golf facility designers and operators** should be aware of the technical aspects of developing a golf facility on a remediated Superfund site. **Consulting engineers** representing the PRPs or owner should be able to assure the regulators that the redevelopment project does not compromise the effectiveness of the remedy. To ensure that the perspectives of all interested parties are considered and that the remediation and reuse of the site complies with all state and federal regulations, coordination with the stakeholders should be initiated early in the planning process and continue frequently throughout the process.

Superfund Redevelopment Program

EPA prepared this report as part of the Agency's Superfund Redevelopment Program. This Program reflects EPA's commitment to consider reasonably anticipated future land uses when making remedy decisions at Superfund sites, and to ensure that, when possible, the cleanup of Superfund sites allows for safe reuse for ecological, commercial, recreational, or other purposes.

Through this Program and other efforts, the Agency works with communities to determine remedial action objectives that will allow for reasonably anticipated future land uses. Land use is a local matter, and EPA does not favor one type of reuse over another. EPA's primary responsibility is to ensure that the remedy is effective in protecting human health and the environment.

The safe and appropriate redevelopment of sites can provide significant benefits to communities and help ensure that remedies will be maintained. These potential benefits include:

- New employment opportunities, increased property values, and catalysts for additional redevelopment;
- New recreational and open-space areas in communities where land available for such uses is scarce;
- Better day-to-day property management, which can result in improved maintenance of the remedy; and
- Improved aesthetic quality of the area through the creation of well-maintained properties and discouragement of illegal waste disposal and similar unwanted activities.

For more information on the Program, including current developments, pilot programs, tools, resources, and case studies, visit the Superfund Redevelopment Program web site at **http://www.epa.gov/superfund/programs/recycle/index.htm or** call the following numbers:

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Integrating Reuse Plans With Cleanup Remedies

Assumptions about the future use of a Superfund site can affect all aspects of the removal and cleanup processes, from the remedial investigation/feasibility study (RI/FS) through remedy selection, design, and implementation. The RPM should consider the proposed reuse in the design of the response actions, consistent with OSWER's land-use guidance, and adjust them when cost and protectiveness are not affected.[1] It is important to understand when and how future land use considerations are incorporated into EPA's site management process and the scope of EPA's authority to accommodate future land use throughout the remedial process.

Consideration of Future Land Uses

The anticipated future uses of land is an important factor that EPA considers in determining the appropriate response action. The process for identifying the reasonably anticipated future land use begins during the Remedial Investigation/Feasibility Study (RI/FS) or Engineering Evaluation/Cost Analysis (EE/CA) stage of the EPA site management process. Assumptions about reasonably anticipated future land use can be considered as part of:

- The baseline risk assessment when estimating potential future risk;
- The development and evaluation of remedial or removal action objectives and response action alternatives; and
- The selection of appropriate response action required for the protection of human health and the environment.

A useful way to develop reasonable assumptions about future land use is to conduct a reuse assessment. The reuse assessment typically identifies broad categories of potential reuse (*e.g.*, residential, recreational, commercial and industrial, agricultural, ecological). This assessment may also initiate the reuse planning process and lay the groundwork for integrating reuse into the cleanup plan. In general, the reuse assessment can be done by the entity conducting the RI/FS or EE/CA. As with other activities performed under the RI/FS or EE/CA, EPA can determine the appropriate level of oversight when PRPs perform this work. While EPA does not expect to be involved in detailed analyses of golf course feasibility, the Agency should ensure that reasonable assumptions regarding future land use are considered in the selection of a response action. This determination should be coordinated with the state.

In some cases, property owners, PRPs, and communities may have initiated a reuse planning process. Information from a reuse plan may also be useful for the reuse assessment. As part of the reuse assessment process, EPA holds discussions with local land-use planning authorities, local officials, property owners, PRPs, and the public to understand the reasonably anticipated future uses of the land on which the Superfund site is located. Based on these discussions, EPA develops remedial action objectives and identifies remedial alternatives that are consistent with the anticipated future land uses. If there is substantial agreement on the future use of a site, EPA may be able to select a remedy that is consistent with that use and take measures to accommodate it when designing the remedy.

EPA must balance this preference for future land use with other technical and legal provisions in the Superfund law and its implementing regulations (National Oil and Hazardous Substances Pollution Contingency Plan, known as the NCP). For example, the Agency's decisions must

[1] U.S. EPA. 2001. *Reuse Assessments: A Tool to Implement The Superfund Land Use Directive*, OSWER 9355.7-06P. http://www.epa.gov/superfund/resources/reusefinal.pdf

conform with NCP preferences for using one or more of a number of approaches, such as treating principal-threat wastes, engineering controls such as containment for low-level threats, institutional controls to supplement engineering controls, and innovative technologies. EPA generally complies with other laws when they are "applicable or relevant and appropriate" (ARAR).

After considering these factors, EPA selects a remedy. In this process, two general land-use situations could result from EPA's remedy selection decision:

- If the remedy achieves cleanup levels that allow the site to be available for the reasonably anticipated future land use, EPA will work within its authorities to accommodate that reuse; or
- If the remedy achieves cleanup levels that require a more restricted land use than the reasonably anticipated future land use, the site will probably not support the community's reuse preferences and the interested parties will have to discuss other reuse alternatives.

For additional information on how EPA considers land use in the remedy selection process, see EPA's *Land Use in the CERCLA Remedy Selection Process*, EPA OSWER Directive No. 9355.7-04; and *Reuse Assessments: A Tool to Implement the Superfund Land Use Directive*, OSWER Directive No. 9355.7-06P, **http://www.epa.gov/superfund/resources/reusefinal.pdf**

Timing

To allow for evaluations of a variety of remediation and reuse options, reuse planning should be initiated as early in the cleanup process as possible. The longer reuse planning is delayed, the greater the possibility that some reuse options will be foreclosed by decisions already made.

There are two major components of the reuse planning process: making reuse assessments and creating reuse plans. A reuse assessment, which typically identifies broad categories of potential reuse (*e.g.*, recreational, industrial), should be developed at the RI/FS stage. This assessment initiates the reuse planning process and lays the groundwork for additional planning. Because the land-use categories employed in making the assessment are broad, they may not provide sufficient detail to ensure that the remedy being considered will allow for a specific use or to guide the detailed remedy design. When communities need more specific and detailed land-use proposals, they may initiate the second component of the planning process—the creation of reuse plans.

Reuse plans are often developed after the RI/FS and may not be available until later stages of the site management process, such as during remedy design or construction. When the EPA receives the reuse plans prior to remedy selection, the site manager should evaluate them in the course of developing the remediation alternatives. When reuse information is received after the remedy is selected, the site manager evaluates it to determine whether the response action is consistent with the proposed reuse and whether design modification might be easily made to accommodate it. If the reuse project plan calls for changes in schedule or other aspects of the remedy, these plans should be evaluated in light of their effect on potential risk to human health and the environment.

Development of a reuse project can sometimes begin on parts of a site before construction of a remedy is completed. This can be done by segmenting the site into different operable units (OUs) which proceed on different schedules according to the nature of the cleanup approaches, location, and expected completion time; deleting portions of the site from the NPL while cleanup continues elsewhere; and sequencing the cleanup work to coordinate with development needs. For example, at the Ohio River Park Superfund site in Neville Island, Pennsylvania, remedial activities were interrupted when EPA agreed to make part of the site available for replacing the old, unusable Coraopolis Bridge, which was important to the community.

In many cases, a completed remedy may not be able to accommodate the planned use without modification because of technical, legal, or other factors. If, in the future, landowners or others decide to change the land uses in a way that makes further cleanup necessary, EPA does not prohibit them from conducting such a cleanup, so long as the effectiveness of the remedy is not compromised. It would be necessary to evaluate the implications of that change for the protectiveness of the selected remedy. Retrofitting an existing remedy to support reuse requires careful planning, design, coordination with, and approval by, EPA and other regulatory agencies. As discussed below, EPA is prohibited from funding, nor can it require others to fund, activities that are considered “enhancements” to the remedy.

Enhancements

EPA is prohibited from funding, and cannot require potentially responsible parties (PRPs) or others to fund “betterments”or “enhancements” of a remedy. Generally, an enhancement is a facility or an activity that is not necessary to support the effectiveness of a remedy, including its continuing effectiveness under the anticipated future use of the land. For example, installation of lights for a parking lot would, typically, be considered an enhancement. Other examples of enhancements would be compaction of a protective cap beyond what might be needed to keep it from settling under anticipated future use, or the addition of clean fill beyond that required to make a remedy protective under the anticipated future use.

Some cleanup activities may be necessary to accommodate the anticipated future use of a site. These are not enhancements because they support the remedy by implementing it in a manner consistent with future use. The effectiveness of a remedy can be compromised if it is not consistent with the eventual use. Therefore, EPA to the extent possible and without compromising protectiveness to human health or the environment, chooses remedies that are consistent with anticipated use, and implements them, insofar as it can, in ways that accommodate that use. For example, the Agency has a preference for not leaving a site with no means, short of modifying the remedy, to support structures that will be required for the anticipated use. The remedy should generally allow reasonable areas for them. As a part of the remedy, EPA may provide corridors of clean soil or other material for future utility access when anticipated use makes the need likely. EPA may also, for example, place wastes in a location where they will not block access that will be needed for the anticipated future use of a site, even though it might have cost less to place them elsewhere. Likewise, EPA may take future use into account in deciding on the placement of monitoring or extraction wells, air-stripping towers, or other treatment units, so that they do not interfere with the placement of structures needed for redevelopment of a site. Such actions would generally not be enhancements.

EPA determines case-by-case whether an activity or feature constitutes an enhancement. Actions like those above may often not be considered enhancements because they accommodate the anticipated future use and thereby support the remedy by helping to ensure its long-term integrity. EPA may fund such actions, or require a PRP to fund them.

The Game of Golf in the United States

Golf was introduced to the United States in the late 1700's, but did not become established until around 1900, when there were approximately 1,000 golf courses in the country. Since that time there have been several periods of substantial growth of the game and many new facilities opened. In the early 1950's, there were an estimated 3 million golfers in the U.S. playing on 5,000 courses. By the end of the 1960's, the number of golfers had grown to over 4 million and the number of courses to about 6,000. By the late 1990's the number of golfers had reached 24 million. These golfers played over 500 million rounds of golf on about 16,000 courses.

According to golf industry sources, the sport's popularity is still growing. Within the next few years the number of golfers is expected to exceed 30 million and the number of rounds played is anticipated to reach 650 million annually. During the late 1990s, between 400 and 500 new courses were being built annually. Based on the projected number of golfers, the demand for new facilities is expected to continue well into the future.

The development of the earliest golf facilities often occurred on sites that were specifically selected for their physical characteristics and ability to produce exciting golf. Since then, other considerations besides the physical qualities of a site have become the deciding factors. Golf course developers evaluate demographic and economic factors. The growth of the game has required that new facilities be more accessible to a greater number of people. New facilities are often being developed in locations that will meet an identified demand, whether or not they offer significant land forms, water features, trees, scenery or other natural features or physical characteristics. A positive outcome of these trends is that a golf course can offer the opportunity to enhance the visual and environmental quality of a featureless site and provide attractive green space and recreation for a community.

Opportunities for Golf Course Development on Degraded Lands

A number of these new courses are being built on degraded lands that no longer support wildlife habitat and may have been previously been rejected for human use because of past contamination. Many of these sites require significant rehabilitation to prepare them for productive reuse of any type. Surrounding communities are usually anxious to have these sites reclaimed and returned to a positive reuse to eliminate visual blight and prevent further water contamination or physical injury from possible accidents. Degraded lands include a variety of sites such as closed landfills, abandoned mines, Superfund sites, brownfields, and portions of closed military installations.

For decades, golf courses have been developed on degraded lands. These include some prestigious and award winning courses, such as the Links at Spanish Bay in Pebble Beach, California; Old Works Golf Course in Anaconda, Montana; and Harborside International Courses in Chicago, Illinois. Although this phenomenon is not new, its importance and acceptance is growing in view of the continued expansion of the game and the need to clean up and rehabilitate contaminated sites. In some urban and suburban areas, where the demand for golf is greatest, degraded sites may be the only properties large enough for golf development. In areas with sensitive wildlife habitats, such as wetlands, extensive environmental permitting requirements or local opposition has sometimes made development difficult. Golf facilities can provide a viable alternative for these properties. In these situations, golf course developers usually gain broad community support for transforming waste sites into attractive and profitable amenities.

Organization of Report

The remainder of this report describes key planning and technical factors to be addressed when golf facilities are to be developed on properties where hazardous waste has been left on site.

Section 2 Planning and design issues associated with developing a golf course on a Superfund site including key questions for the golf facility reuse decision-making process.

Section 3 Common remediation methods and design factors to be considered when a golf facility is to be placed on a Superfund site. The key issues include site remedy components, settlement, gases, utilities, surface vegetation, storm-water management, construction techniques, groundwater extraction and treatment, operations and maintenance, and institutional controls.

Section 4 Operation and maintenance activities that are required to protect the integrity of the selected remedy for a Superfund site.

Section 5 Four projects where golf courses have been built on degraded lands. The discussion for each site includes its history, contamination problems, and key factors considered during remediation and reuse planning. These case studies demonstrate how remediation and reuse efforts may complement each other.

Bibliography The references are grouped by technical subjects in order to allow the reader easy access to the many sources that are available for hazardous waste remediation and golf course design.

Appendix A Golf industry information sources for golf facility reuse.

Appendix B A list of Superfund sites that include golf facilities, along with contact information.

Appendix C Defines acronym's used in this report.

Section 2. Factors Affecting Planning and Designing Golf Courses on Superfund Sites

A thorough understanding of the physical conditions of the site and the economic characteristics of the area is necessary to determine the feasibility of a proposed golf course and provide information required for the planning and design process. This chapter discusses factors addressed in determining golf facility feasibility, coordinating a golf course project with the Superfund remediation process, and the planning and designing a golf facility. Remediation design and planning issues are discussed in Section 3.

Typically, a golf development project will use a team of professionals including a feasibility and market analyst, an environmental specialist familiar with local issues, an engineer for remediation issues, and an experienced golf course architect. The golf course architect and initial team members are often joined by other qualified experts, such as a land planner, civil and hydrologic engineer, traffic specialist, facilities architect, landscape architect, and golf course superintendent for the planning and design of the golf course.

Components of a Golf Facility

Golf facilities consist of golf courses, driving ranges, other practice facilities, miniature golf structures, or a combination of these. A course requires items such as tees, greens, fairways, and sand bunkers. A clubhouse or operations building typically contains a pro shop, food service, restrooms, offices, storage areas for supplies and equipment, and space to house golf carts. A maintenance building provides areas for offices, employees, equipment storage and repair. A separate building may be required for the storage of pesticides and fertilizers. Other buildings are necessary to house the irrigation pump station, on-course shelters and restrooms. These buildings generally require space for parking, deliveries, and waste removal. To accommodate these requirements, a golf facility needs land with appropriate topography and access to utilities and other infrastructure.

> A regulation golf course requires between 150 and 300 acres. Smaller courses and driving ranges require less land, some as little as 10 acres. Miniature golf facilities only require 1 to a few acres.

Land Requirements. Because there are no established standards for the size and configuration of golf facilities, they may be built on a wide variety of remediated Superfund sites. Depending upon the topography of the proposed site and environmental or other constraints, an 18-hole regulation golf course typically requires between 150 and 230 acres of land. In some cases, a championship-length course can occupy as much as 300 acres. Executive length golf courses containing mostly par 3 holes, short par 4s and an occasional short par 5 require between 60 and 125 acres. Par 3 chip and putt courses require between 25 to 50 acres.

A driving range with 35 to 40 tee stations requires an area approximately 240 yards wide by 300 yards in length (about 15 acres). Additional length is required if another teeing area is provided at the back end of the range for instructional purposes or if the topography, predominant winds, or elevation of the site is a consideration. The teeing area, fairway and surrounding rough areas of a driving range require from 15 to 25 acres or more, including the operational facilities and parking area. A driving range can be constructed on a smaller area by reducing the number of tees or by using netting to contain errant golf balls.

Miniature golf facilities may be constructed either indoors or outdoors. An 18-hole course may require between 1 and several acres. Miniature golf facilities may include water and sand hazards, windmills, and moving obstacles.

Topography. The topography can have a substantial influence on the design of the facility and the cost of maintenance. The topographic elevations and slopes of the site should be conducive to the playability and maintenance of the golf facility. Most golf course designers seek to avoid extreme changes in elevation and severe slopes, to create a facility that offers all players a fair and enjoyable experience and facilitates efficient maintenance. The role of topography in remediation and construction of the golf course is discussed later in this section.

Local Infrastructure. The critical infrastructure needs for a golf course include roads and utilities, such as water, electricity, natural gas, sewers, and telecommunications. A golf course cannot exist unless the water source is reliable and of a quality that is compatible with turfgrass. Potential sources include groundwater, surface water, municipal water, and recycled on-site water.

Coordinating Golf Course Planning with the Superfund Process

As discussed in Chapter 1, the future use of a property can affect all aspects of the removal and cleanup processes. Likewise, the requirements of the remedy will affect many aspects of golf facility design and operation. The objectives and requirements of golf course development and those of remediation are best accomplished if they are carefully coordinated. Thus, it is imperative that the remediation team understand the golf course development process, and that the golf course planners work within the superfund site management process. The process begins with bringing together the golf facility development team with the cleanup team.

Golf Development Process Time Line. The development of a golf facility is a complex process that begins with site analysis, planning, and design and progresses to construction, establishment, and operation. Planning includes evaluating alternatives for a project, a feasibility study and market analysis, a review of all environmental constraints and regulatory requirements, and the development of a conceptual plan. Once the design of the facility has been reviewed and approved by the appropriate regulatory agencies, construction drawings are prepared and implemented. The facility will then undergo a grow-in period to establish the turfgrass and produce the proper playing conditions prior to opening for play. The golf facility development process typically involves the steps shown in the box.

Typical Golf Facility Development Process

Feasibility Stage
- Site analysis for physical and environmental constraints and opportunities

Conceptual Planning Stage
- Conceptual planning for the golf course
- Planning for environmental issues, improvement, and mitigation
- Pre-application regulatory review
- Preliminary estimating for construction and operation costs

Planning, Design, and Construction Stage
- Master planning and detailed design for the golf course and operation and maintenance facilities
- Construction documentation for the golf course
- Regulatory and permit review and approval
- Construction of the golf course and maintenance facilities
- Establishment of the golf course and construction of ancillary facilities
- Opening the golf course for play

Operation and Maintenance
- Monitor, repair and maintain turf and other vegetation, greens, fairways, buildings and roads

Superfund Process and Time Line. The Superfund cleanup process begins with the discovery of hazardous waste or notification to EPA of possible releases of hazardous substances. Once discovered, EPA investigates the potential for a release of hazardous substances and, if necessary, conducts or oversees a remedy. The steps are shown in the box.

Superfund Process and Time Line

- Preliminary Assessment/Site Investigation (PA/SI), which involves an initial review of the site
- Hazard Ranking System (HRS) Scoring, which is a screening mechanism used to decide whether to place sites on the National Priorities List (NPL)
- NPL Site Listing Process, which allows for public comment prior to listing a site on the NPL, after which it is considered a Superfund site
- Remedial Investigation/Feasibility Study (RI/FS), determines the nature and extent of contamination and its fate and transport; and identifies risks and cleanup alternatives
- Record of Decision (ROD), which describes the selected remediation approach
- Remedial Design/Remedial Action (RD/RA), or preparation and implementation of the remedy
- Construction Completion, or completion of the construction phase of the remediation
- Operation and Maintenance (O&M), which are activities to ensure that the remedy is effective and operating properly after remedy construction is completed
- NPL Site Deletion, removal of sites from the NPL

The table below compares the typical times for each phase of the Superfund cleanup process, with the critical phases of a golf facility development project. These times can vary widely from one site to another.

Exhibit 1. Comparison of Superfund Process and Golf Facility Development Time Lines

Phase	Approximate Time (years)	CERCLA Task	Golf Facility Input
Identification	½ to 1	Preliminary Assessment/Site Inspection (PA/SI)	**Feasibility Stage** Complete site analysis for physical and environmental constraints and opportunities
Investigation and Alternatives Evaluation	1 to 2	Remedial Investigation/ Feasibility Study (RI/FS) • EPA conducts Reuse Assessment (includes "recreation" as an alternative) • EPA conducts human health and ecological risk Assessments	**Conceptual Planning Stage** • Team Created (includes all stakeholders)* • Coordination meetings held • Planning for environmental issues, improvement, and mitigation • Pre-application regulatory review • Golf designers plan for environmental issues, enhancement, and mitigation • Conceptual planning for the golf course layout and budget
Decision	½ to 1	Record of Decision (ROD)	**Remedy Decision** EPA selects a remedy, including consideration of the reuse alternative
Design	1 to 2	Remedial Design (RD)	**Planning, Design, and Construction Stage** • Selected remedy is designed, include golf facility features agreed upon • Master planning for the golf course • Selected remedy is built • Golf facility is designed and built • Golf facility undergoes establishment • Golf operations begin
Cleanup	1 to 2	Remedial Action (RA)	
Operations	30	Operation and Maintenance (O&M)	

* Stakeholders typically include potentially responsible parties, property owners, local government, local citizens and groups, EPA and other federal regulatory agencies, state and local regulatory agencies, environmental organizations, consulting engineers and environmental specialists, and golf facility designers and operators.

As discussed in Section 1, the earlier the redevelopment planning begins, the more likely it is that the project will be a success. Throughout the process, all stakeholders should be involved to allow the planners to identify and address all concerns in the facility design and to develop innovative designs that result in enjoyable play and an efficient golf facility.

Determining Golf Course Feasibility

Golf course projects typically begin with an evaluation of the feasibility of success of the project. The feasibility analysis provides investors and communities with an early indication of whether or not it is worthwhile to pursue this land use. It will also indicate to the RPM and other remediation planners whether it is reasonable to anticipate that the future land use will be as a golf course.

Feasibility of the golf course depends on economic, demographic, physical, and environmental factors. Planners typically address such questions as the level of potential risk to golfers from contaminants remaining at the site, the ability of the local economy to support the facility, the availability of utilities and other infrastructure, and the size and configuration of the site.

Key Questions Addressed in the Feasibility Analysis:

- What are the risks to golfers or workers if a golf facility were placed on the waste site?
- Is the location economically viable for a golf facility and will the community support the development of a golf facility?
- Is the current local infrastructure sufficient to support the location of a golf facility?
- Is the land (areal size and grade) suitable for a golf facility?
- What restrictions are presented by the site remediation and subsurface conditions?
- What environmental or other physical considerations should be taken into account?

Health, Safety and Environmental Impacts

Golf course developers and operators need assurance that their customers and employees will not be subject to adverse health and safety conditions and that the facility will not adversely impact local or regional ecosystems. The most obvious risks relate to direct exposure to wastes, contaminated groundwater, and containment system gases.

For the most part, the developer may rely on information generated during the Superfund site management process. The evaluation of these risks will usually require information similar to that collected in the risk analysis done during the RI/FS. However, the role of the analysis in the overall development process will differ according to whether the feasibility study is conducted after the remedy design and construction is completed or whether it is begun earlier in the Superfund process.

Remedy Construction Completed. At sites where the remedy is already built, golf course planners can review as-built drawings of the remedy and consult with EPA to ensure that the remedy will safely support a golf facility. Key issues of concern include the anticipated settlement, type and location of systems used to collect and treat gas and groundwater, and restrictions on the use of irrigation systems and chemicals. Generally, if the site is considered safe for recreational use, the site agreements would not preclude a golf course. However, the golf course designers will have to consider the location of, and access to, remedy components such as monitoring wells and treatment systems; the need to restrict public access to certain areas; and any site restrictions agreed to during the remediation.

Early-Stage Feasibility Analysis. When the feasibility study is conducted early in the remediation process, such as during the RI/FS stage, golf facility planners may have more flexibility in ensuring that the remedy is built to minimize any potential adverse impacts. A risk assessment that will determine if the site is suitable for recreational development is conducted as part of the RI/FS. Golf course planners can evaluate information from EPA's risk assessment to determine whether the alternatives would leave the site safe for golfing. They can work with the remediation design team to ensure that future infrastructure needs are considered when remediation features are developed. For example, extra fill, land contouring, or gas monitoring can be planned as part of the remediation to provide adequate protection to golfers and workers.

Environmental risks include the impact of the proposed course on wetlands, surface waters, groundwater, areas of significant wildlife habitat, and migration routes or access corridors. Potential threats to the environment can include chemicals used at the course, contaminants released from containment systems, and the withdrawal of water for golf course irrigation. An ecological risk assessment is prepared during the remedial investigation to assess impacts to natural resources. The ecological risk assessment identifies ecological receptors of concern, such as threatened and endangered species, critical habitats, and wildlife migration corridors. It also identifies contaminants of ecological concern and ecotoxicity values for the receptors of concern. Ecological resources include surface and groundwater quality, aquatic species, flora, and fauna. Information from these assessment can be used by golf course planners to help identify environmental resources and potential environmental impacts that need to be considered in the golf course feasibility analysis and design.

Economic Viability and Community Support

The economic viability of a golf facility is determined by the demand for golf in the area and construction and operating costs. Prospective developers or other stakeholders conduct a market study to estimate the likely revenues from the facility. A market study typically provides data on the location and types of competing existing and planned facilities, the geographic area likely to be served by the proposed golf course, area population and demographics, percentage of golf participation, and average household income. The existing infrastructure of the area and other resources are examined to develop a preliminary estimate of a range of costs for the golf course construction and operation. These data are combined to assess the potential for economic success of the project and alternative financing methods.

The stakeholders also typically investigate whether the golf course is compatible with long-range plans for the area, current and anticipated zoning, community goals, and features of historic or archeological significance. Local political and community groups should be consulted regarding their perspectives about the proposed project. The development of a golf facility at a Superfund site location requires the support of the local community.

At the McColl Superfund site in Fullerton California, meetings with residents and community groups were held to ensure agreement that a golf course was the preferred land use.

Local Infrastructure and Resources

The critical infrastructure needs for a golf course include roads and utilities, such as water, electricity, natural gas, sewers, and telecommunications. The feasibility analysis generally includes an assessment of the availability and cost of these items and an assessment of whether the increased demands on the infrastructure would be acceptable to the community.

A golf course cannot exist unless it has a reliable source of water that is of a quality compatible with turfgrass. The study team will need to assess its availability, quantity, flow rate, cost, (commodity and pumping), and quality. Potential sources include groundwater, surface water, municipal water, and recycled on-site water. Water quality can be classified by its characteristics (physical, chemical, biological) or by its suitability for a particular use.

Groundwater from an aquifer may be used if the supply is not seriously curtailed by seasonal events and withdrawal does not adversely affect the supply for adjacent properties. Surface water rights, quality, and flow quantity should be determined. Surface water may contain sediment, which must be removed before pumping through an irrigation system since it could foul the system. A pump inlet can be located within a stilling well to minimize sediment intake.

Municipal water is an option if available at a reasonable cost. Non-potable water (treated sewage and other wastewater effluent) has been used to irrigate golf and other similar areas, particularly where water supplies are limited and prices are high. Usually, discharged effluent is treated to a level acceptable for golf course use. Nevertheless, it is prudent for the golf facility operator to test it to verify the chemical content, identify any potential risks, and determine whether it can support turfgrass. Although effluent can be a reliable irrigation-water source, it may pose additional design and maintenance considerations.

Suitability of Site

Golf facilities may consist of a golf course, a driving range and other practice facilities, miniature golf facilities, or a combination of these, as well as structures to support member services and operations and maintenance. The key factors that will determine the suitability of the site for a golf facility include the property size and topography, the need for facilities such as club houses and maintenance areas, existing drainage patterns, and the type of vegetation suitable for the area.

Land Requirements. The feasibility study should determine whether or not the site is large enough to support the contemplated facility. Because golf facilities can range from a few acres to several hundred acres, many Superfund sites might be candidates for this type of use. The acreage requirements of different types of golf facilities is discussed earlier in this section.

Ability to Support Structures. As discussed earlier in this section, a golf course will include structures for club houses and maintenance and paved areas. The feasibility study should address the site's ability to support the required structures. Concerns with placing structures on Superfund sites include settlement, adequate support for building foundations, gas management, utilities, and site access. These topics are addressed in section 3 of this report.

Topography. While golf courses have been built on a wide variety of topographies, there may be some sites where designers cannot develop a workable golf course. The feasibility study should evaluate the likelihood that topography will preclude a golf facility. The role of topography in golf course design and construction is addressed later in this section (under Design and Construction Factors). However, the feasibility study need not be restricted to the existing site topography. It is often possible to create different site contours during the remediation process. Planners may develop a conceptual design and work with the remediation team to consider contouring options that support the intended future use.

Site Drainage. The site should have drainage that is adequate to prevent storm water from damaging remediation and golf facility features and off-site areas. Storm-water management systems generally must also maintain water quality and possibly improve aquatic and terrestrial habitats. Storm water can be routed to support aquatic habitat, function as an irrigation supply, or be drained quickly to detention facilities on site. Storm-water management measures are often incorporated into the golf courses as design features, such as steep slopes or swales to direct runoff, tall grass or other vegetation to minimize soil loss, and water detention ponds. The golf course architect and engineer at Harbor International collaborated in the design of an elaborate drainage system where all site drainage is collected and stored at seven dry detention locations within the site and routed back to a sewage treatment plant for processing. This arrangement allowed for extra retention capacity so that the golf center runoff would not overwhelm the sewage treatment plant after unusually heavy precipitation.

Design storm event specifications (duration and intensity) are chosen to provide protection against all events likely to occur within a determined interval. Discharge estimates are typically determined for a 25-year, 24-hour storm event. State and local agency requirements should also be incorporated.

Conditions for Golf Course Vegetation. During the feasibility study, golf course planners determine whether or not turfgrass and other plants suitable for a golf facility can be successfully established on the site. They typically make this determination by examining climate, precipitation patterns, soil characteristics, geology, and other site-specific factors that affect vegetation. Sometimes it is necessary to consider restrictions on the use of irrigation, fertilizer and herbicides, or other factors that result from the remedy. The consideration of vegetation in designing and building golf courses is discussed later in this section.

Geology. Geological information, such as depth to bedrock and presence of groundwater and surface water is used for evaluating construction needs, estimating costs, and determining the availability of irrigation and potable water. Soil and geology maps are available from the USGS. Geotechnical information may also be available from local well logs and the Remedial Investigation.

Vegetative Cover. A map of the existing vegetative cover in the area is prepared to identify the location and predominant type of plant material on the site. The information pertains mostly to trees and understory vegetation. However, plant communities and areas of environmentally sensitive habitat should also be inventoried. Information on threatened or endangered species must also be collected to identify any special actions that may be needed. This effort usually requires field reconnaissance to locate specimen quality trees and other sensitive plant material. Existing trees, understory, and other naturally occurring vegetation are often incorporated into the design of the golf course as features and natural resource conservation areas.

Adjacent Land Use. The golf course operation should not conflict with adjacent land use. For example, if nearby highways or sidewalks cannot be shielded from flying golf balls, the site may not be suitable. Similarly, the area's land-use plans may indicate potential problems in the future. For example, if the plans call for schools, playgrounds, commercial facilities or transportation facilities too close to the course, alternative plans will be necessary.

Restrictions Resulting from the Remediation

The remedy may preclude or limit the design options for a golf facility. For a site where the remedy has already been built, a golf course designer must consider the requirements of the existing remedy. These requirements may include restrictions on the types of activities allowed on the site. If the remedy is not yet built, course designers can work with the remediation team to develop the facility. In either case, the following are the primary factors that must be considered.

Final Grades. The final grades of a closed site are influenced by the site topography and regulatory and design considerations. Many landfills and other containment areas have a relatively flat top surface with steep side slopes which may not be desirable for golf facility reuse. Side slopes may be flattened by regrading the existing contours or increasing the foundation layer or topsoil/vegetative layer thickness. When possible, the features and grading requirements of the golf course should be considered in the design of the closure contours for the containment area, providing EPA does not incur extra costs, nor *require* a PRP to incur extra costs, beyond those necessary to ensure protection of human health and the environment, as explained in the discussion on “enhancements” on page 6.

A minimum gradient of two percent is normally required to facilitate surface drainage. Where differential settlement is anticipated, minimum slopes of 3 to 5 percent are often used to improve surface drainage and the operation of the internal drainage system. Internal drainage systems can be designed with the appropriate pipes and couplings to withstand minor settling.

Soil Type and Depth. The soil type and depth of protective covers used at closed sites are typically based upon locally available materials and the remedy design. Soil selected for use on the surface should be tested for its ability to support turfgrass. Cover depth can vary from 1 foot to several feet, depending on the waste characteristics, climate, and regulatory requirements. For golf reuse, the minimum depth of the protective cover should be 2.5 to 3 feet to accommodate the installation of an irrigation system.

Containment System. Containment systems may include features such as protective covers, drainage systems, subsurface barrier walls, and monitoring equipment. Some systems may be subject to settling or produce gases from decomposing subsurface materials. Section 3 includes descriptions of containment system types and components and discusses settlement, managing gases, and related matters. Golf course designers generally consider these issues, as well as the specifications of the containment systems to ensure that a golf facility can be built without hindering the effectiveness of these systems.

On-Site Treatment and Monitoring Systems. The final remedy may include measures to extract and treat groundwater above ground, treat groundwater and soil in the subsurface, collect and treat potentially harmful gas, and monitor groundwater. Some of these activities may need to continue for many years.

Institutional Controls. The remedy may include post-cleanup restrictions on the type of activities allowed on the site, such as drilling wells or using heavy vehicles. There may also be requirements to minimize impacts to environmentally sensitive areas. Such restrictions and requirements are referred to as “institutional controls.”

The considerations involved in developing the initial conceptual plan and the planning, design, and construction of golf courses on remediated areas are discussed in the following section.

Golf Facility Conceptual Plan

A conceptual plan outlines, in general terms, the proposed golf facility configuration, the approximate location of major features, the source for irrigation and potable water, how it would fit in with the surrounding area, how it would address any ecological and other issues raised during the feasibility study, and how it would relate to a proposed remediation. This plan is used to communicate to the remediation team and other stakeholders the general specifications and resource requirements of the golf facility. ÉPA and other remediation team members can consider this information in the course of conducting the reuse assessment, RI/FS, and remedial design.

The concept plan builds upon the information and analyses assembled during the feasibility study. It addresses many of the issues that would be faced in the course of designing, building, and operating a golf facility, but at a less detailed level.

Golf Facility Design and Construction Considerations

Containment systems are generally designed and built in accordance with accepted remediation design principles. Because there are no rigid specifications for golf course layout and design, designers can be creative in developing facilities that are compatible with the area and the remedy. To ensure that the facility does not hamper the effectiveness of the remedy there are several additional design and performance issues to be addressed. The case histories in Section 5 provide some examples of creative design and engineering approaches to building golf facilities on degraded land. The key design and construction factors to consider developing golf facilities on containment areas are:

Course Configuration and Topography

The configuration of a golf facility, such as a core or linear type, is determined by the characteristics of the site and design objectives. A linear-type course contains ribbons of grass running through a landscape, sometimes stretched out over considerable distances. A core type course is designed as a big, open-space core area of green space in which the holes play toward internal points on the property. The holes often border each other, although they are often hidden by a variety of creative features. A core-type course is more of a contained environment than a linear type course. Houses or roads are generally not visible from most of the course. Housing may be along one or more sides of the facility, but would not surround each fairway as may be true of a linear course.

Because there are no rigid specifications for golf course layout and design, designers can be creative in developing facilities that are compatible with the area and the remedy. For example, the course could be laid out so areas frequented by golfers, such as greens and fairways, are not located in areas where monitoring wells are to be placed. If a detention pond is needed, it can be used as an attractive landscape feature. Golf courses have been built with wetlands and other natural or man-made features on the property.

In designing golf courses, designers generally seek to take advantage of topographical features to route the course and create interesting and pleasant landscape features that enhance the play. Many designers avoid severe slopes so that power-riding equipment can be used for efficient maintenance and all players can negotiate the course in a reasonable amount of time. Extreme changes in elevation resulting in long uphill climbs may discourage players from electing to walk the facility. However, the design of the course need not be restricted to the existing site contours.

Consideration of these factors can also influence the remediation design. Using a conceptual design of the golf facility, remediation engineers can often contour the site during the remediation to make it suitable for play and golf-course maintenance, providing EPA does not incur any costs, nor *require* a PRP to incur extra costs, beyond those necessary to ensure


Photo: Mike Kemee, Golfoto, Inc.

At the Harbor International Golf Center in Chicago, fairways, greens, and bunkers were crafted with the use of wastewater biosolids blended with other locally available materials, to form a contoured golf course out of the previously flat topography.

protection of human health and the environment, as explained in the discussion on “enhancements” on page 6. Appropriately designed elevations and slopes can be beneficial for protecting containment systems, managing storm water, and facilitating enjoyable golf. It is sometimes possible to create different site contours during or after the remediation. For example, at the Harbor International Golf Center in Chicago, the site was re-contoured during the remediation to adapt it for a golf course, at no cost to EPA.

Golf Course Features

The major features of a golf facility, such as tee and green complexes, ponds, and golf cart paths must be designed and built to not interfere with the protectiveness of the containment system. To the extent possible, the course features are typically designed to be compatible with the existing landscape. The key golf course features are discussed below.

- **Tee and green complexes** are designed to support very specific types of turfgrass and require explicit maintenance practices. These features, especially green complexes, utilize special materials and sub-surface drainage systems. In areas of landfill or remedial activity, tee and green complexes should be elevated above the cover components.

  The features of the individual golf holes are typically elevated above the existing grades to provide visibility from or to the features and define the intended golfing strategy and challenge. The elevation of the features can also facilitate the surface drainage required for maintenance purposes. It is important to consider the potential impact of additional fill material on the cover system or other remedy components.

- **Sand bunkers** require special construction techniques and sub-surface drainage systems to limit water infiltration. Bunkers create a natural catch basin for precipitation that quickly infiltrates through the sand in the bunker. Typically, subgrades of bunker cavities are compacted and often treated or lined. The Internal drainage system is installed beneath the bunker cavity to remove water and prevent infiltration.

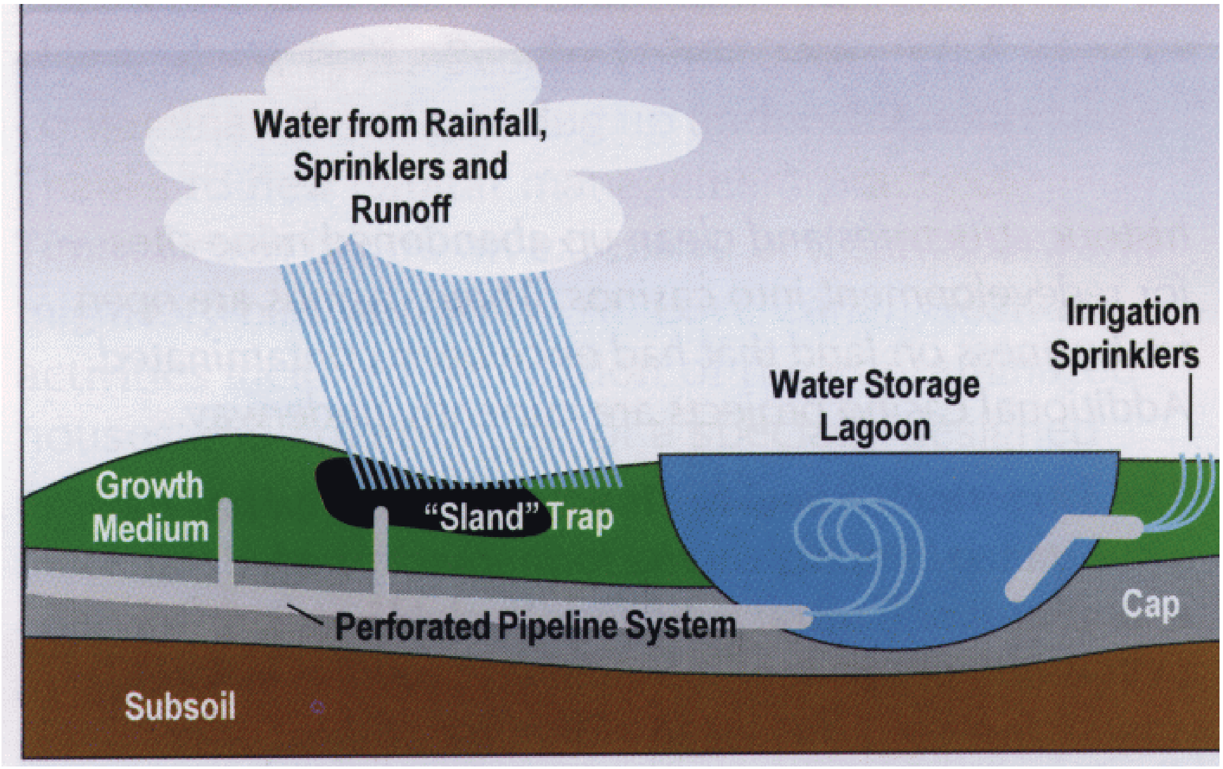
- **Ponds** add to the golfing experience and can provide habitat for wildlife. When used as part of the storm-water management system, ponds allow sedimentation and flow equalization. Ponds can be incorporated into irrigation systems to provide storage basins, thereby allowing for a smaller pumping capacity, offpeak water storage, and possibly less demand from the aquifer or other source.

  When ponds are located over uncontaminated material, they can also serve as groundwater recharge areas. Recharge areas can help to contain contaminated groundwater or serve to direct groundwater flow to enhance capture and treatment systems. When ponds are located over contaminated material, they generally must be lined with a hydraulic barrier system to prevent leachate generation and contamination of the groundwater.

Irrigation Systems

Depending on climate, soil, size of the facility, and turfgrass selection, an 18-hole course may require as much as 1 million gallons of water per day in an arid region or as little as 100,000 gallons per day for a water conserving course in a region with ample precipitation. On average, fairways require approximately 1 inch of water per week, while greens and tees require approximately 1.5 inches per week. Thus, the irrigation system is an important aspect of a golf course and it is not easily modified once installed.

Irrigation systems must be designed and installed to prevent penetration of the hydraulic barrier layer, and not reduce the effectiveness of the remedy. The system may require specialized materials and hardware to counteract the effects of minor settlement. Some systems may require installation of an internal drainage layer. Irrigation piping may be installed in utility corridors with a secondary containment system and possibly leak detection systems. Maintenance and inspection of irrigation systems is required to ensure detection and repair of leakage, breaks and malfunctions.



At the Old Works golf facility built on the Anaconda Smelter Superfund site, Anaconda, Montana, infiltration from irrigation and rainfall is recycled to support the vegetation on the fairways. The clay and limestone cap prevents the recycled water from coming into contact with any remaining contaminants.

Utilities

Operation and maintenance facilities for a golf course will require utilities such as water or well systems, electrical power for buildings and the irrigation pump station, natural gas, storm drains, and sewer or septic systems. Locations and any right-of-ways for existing utilities on site are generally identified in the initial site reviews. Engineering and installation of new utilities should be coordinated with the golf facility design and remediation activities. There are a number of techniques for installing utilities above, near, or in containment systems. These techniques are discussed in Chapter 3.

Vegetation

Vegetation at golf courses can be grouped into two types: turf grass and landscaping plants.

Turfgrass. Turfgrass should be selected from locally compatible species that do not require excessive water or chemicals to maintain a good stand. Golf course quality can be enhanced and maintenance minimized if the selected turfgrass is disease and insect resistant and tolerant of environmental stresses such as drought, heat, cold, and shade. Sometimes, the remediation design will influence decisions on vegetation types. For example, if the remediation requires limitations on irrigation or the use of fertilizers, landscapers can use grass species that require less water and fertilizer. Sometimes, there is a trade-off between a more lush grass and a less lush species that requires less of these ingredients. Designers of the Widow's Walk Golf Course, Scituate, Massachusetts selected drought- and disease-resistant grasses that require little fertilizer. This decision involved the trade-off of using a less lush turfgrass that is not green all year long.

Landscaping Plant Selection and Placement. Landscaping plants, such as trees, understory plants, and native or ornamental grasses are used as integral features of the golf facility to provide visual quality, pleasant surroundings, and a more natural setting. Landscaping also serves to emphasize the intended golfing strategy and challenge of the individual golf holes.

The placement of the landscaping elements is critical to the operation and maintenance of the individual golf holes. Trees and other landscaping elements are usually located around tee and green complexes to prevent excessive shade and lack of air circulation, which could adversely affect turfgrass. The selection and location of plants should allow for their growth. Landscaping located in proximity to the golf holes, while attractive and unobtrusive at a smaller, installed size, will often have an undesirable effect when plants reach full size. Deep-rooted vegetation is typically not planted on a cover system where roots might penetrate an internal drainage or hydraulic barrier layer. An ecologist or landscape architect may be consulted to select appropriate vegetation varieties. Vegetation can also be used to enhance wildlife habitat.

Natural Areas and Wildlife Habitat

As discussed earlier in this chapter, a golf course should be built to minimize adverse impacts on nearby habitats. The primary considerations in protecting habitats include controlling runoff and the use of chemicals to avoid degrading groundwater and surface water resources. Golf courses can also be designed to enhance natural areas and wildlife habitats. For example, vegetation buffers adjacent to water features can serve as filters to reduce the sediment, nutrient, and pesticide loadings to nearby surface water.

A wildlife habitat requires food, water, shelter, and living space. Food requirements vary by species and may include plants, insects or other animals. Water requirements also vary. Some wildlife require running water, some require stagnant water, and some can get water from dew. Shelter is needed to provide protection from predators and the weather. Shelter also provides areas for feeding, breeding, nesting, and resting. Living space varies by species, from a few square yards to many square miles. Generally, the larger the area, the greater the diversity of species, and the healthier the ecosystem.

Vegetation on and near a golf facility may be combined with other features to enhance wildlife habitat and prevent adverse impacts on nearby areas. The type of vegetation should be chosen to reestablish native habitat or to encourage a particular type of wildlife habitat. For example, woodlands with shrubs and smaller trees interspersed among taller trees support a variety of wildlife. Examples of other useful features are bird nest boxes, artificial water sources, bird feeders, dead trees, brush or rock piles, cliffs, and cut banks. Tree planting and other landscaping can also be used to shape and divide areas, create natural barriers, buffer noise and improve the aesthetics of a site. A landscaping plan should be developed to encourage wildlife populations to flourish. In developing the landscaping plan, the designers should consider the following:

Photo: Mike Kemee, Golfoto, Inc.

To protect an underlying aquifer, designers at the Widow's Walk Golf Course selected drought- and disease-resistant grasses that require little fertilizer. The site also included a number of wildlife enhancement areas which also added to the course's attractiveness.

- How do wildlife use the site and what is the desired wildlife use?
- How does the site fit into the surrounding area's wildlife habitat?
- What native vegetation exists and what mix of vegetation supports the desired wildlife?
- How can large areas of native vegetation be incorporated into the design?
- How can smaller areas be included and linked to each other and to larger areas?
- What vegetation transition zones are required?
- What vertical vegetation structure is desired?
- Are food supplies for animals, including year around supplies, adequately addressed by the vegetation?
- Is the intensity of land use compatible with the wildlife?
- Are there wildlife refuges adjacent to the site or can any be created?

Vehicle and Pedestrian Traffic

Traffic systems can be designed to provide for the safe and efficient movement of vehicles and pedestrians into and through the golf facility. Guidance for the geometric design of roads is available from the American Association of State Highway and Transportation Officials (AASHTO) in the document, "A Policy on Geometric Design of Highways and Streets." Pedestrian systems include sidewalks, crosswalks, traffic control features, curb cuts and ramps.

Pedestrian activity that is not related to the golf facility should be avoided within or immediately adjacent to all playing areas of the golf course. When pedestrian systems such as trails are to be incorporated in the site, consideration should be given to appropriate setbacks and distances from all playing areas for safety purposes. To prevent conflicts and safety issues, access to golf cart path systems should be limited to the patrons of the golf facility and maintenance staff.

Section 3. Remedial Design Considerations for Golf Facility Reuse

At most sites, remedies and golf facilities can be structured to safely accommodate each other and meet all the federal and state regulatory requirements for containment systems. To accomplish these goals, the site managers and other stakeholders consider the types of remedial approaches that are available and site-specific remedial design issues.

Remedial Technologies

Numerous remedial technologies can be used to clean up a Superfund site. The remedy that is appropriate for a given site depends on waste or contaminant characteristics, ability to implement, effectiveness, cost, anticipated future land use, and other factors. Several remedial technologies are often utilized at the same site. For example, remediation of a site may include a cover system, groundwater collection and treatment system, and diversion wall.

Containment System Covers

Cover systems at containment sites are used to minimize the infiltration of water into the contaminated material and serve as protective barriers to isolate contaminants from the public and the environment. Regulations under CERCLA and SARA generally require that cover systems at Superfund sites attain, at a minimum, applicable or relevant and appropriate requirements (ARARs). Common ARARs for containment systems at Superfund sites are Subtitle C and Subtitle D of the Resource Conservation and Recovery Act (RCRA) and state regulations. Although cover systems at Superfund sites are not necessarily based on RCRA closure regulations, RCRA requirements are the prevalent basis for cover system design. RCRA and state regulations usually require that the cover be built to:

- minimize the migration of liquids through the system over the long term,
- function with minimum maintenance,
- promote drainage and minimize erosion, and
- accommodate settling and subsidence.

EPA encourages flexibility in the design of waste site covers. They can range from a simple soil or asphalt layer to protect people from contact with the contaminants, to multi-layered composite caps recommended for more demanding situations. General design requirements are based on federal or state criteria.[2] Cover systems can use one or more of the following types of barriers:

[2] For example, RCRA Subtitle C closure requirements for hazardous waste management facilities (40CFR 264.310).

- **Hydraulic barriers**, the most common of the five barrier types, use low-permeability material to impede the downward migration of water. They are usually multi-layered cover systems that typically incorporate geomembranes, geosynthetic clay liners, compacted clay liners, or a combination of these as the hydraulic barrier or barriers. These systems may also include features such as a gas venting layer, biota layer to prevent burrowing animals or plant roots from damaging the cover systems, drainage layer, and soil and vegetative or other top layer. In some cases, asphalt or other materials may also be used as a barrier. Currently, multi-layered hydraulic barriers are the most common type of cover system, and are typically used at RCRA "Subtitle C" and "Subtitle D" facilities that require covers.

- **Capillary barriers** are intended for use in arid to semi-arid climates where unsaturated soil conditions prevail. This type of cover exploits the differences in pore water pressure potential between fine and coarse-grained soils to limit the downward movement of water. A simple configuration of this type of cover system consists of a fine-grained soil (clay) located over a coarser-grained soil (sand). Under unsaturated conditions the fine-grained clay holds water, preventing its movement to the lower coarse-grained sand. However, when the entire fine-grained layer becomes saturated, it will release water to the lower coarse layer.

- **Evapotranspiration barriers** are also used predominantly in arid and semi-arid environments. This type of cover typically consists of a thick layer of relatively fine-grained soil, which is capable of supporting vegetation. It provides sufficient water storage capacity to prevent water from moving into the waste area. The water subsequently becomes available for uptake and transpiration by vegetation. Evapotranspiration barriers are built to have a greater storage capacity than that needed for the maximum anticipated rainfall.

- **Direct contact barriers** provide a physical barrier against contaminants that are contact and ingestion hazards. These covers are typically 1 to3 feet thick, but can be thicker. In addition to functioning as a contact barrier they also provide some protection against erosion and shallow digging. Soil covers are often economical because they typically consist of low-cost fill materials covered with a few inches of topsoil to support vegetation. These types of covers are commonly used in areas with low-solubility metal or asbestos contamination, because these contaminants are less likely to migrate and contaminate the local environment.

- **Surface soil covers** also provide a physical barrier against contaminants that are contact and ingestion hazards. These types of covers are often up to 1 foot thick and constructed over contaminated soil that has been stabilized and is unlikely to migrate. Surface soil cover systems are usually vegetated to prevent erosion and restrictions on disturbing them are normally imposed to prevent exposure of contaminated materials.

Depending on site-specific conditions, cover systems may be composed of multiple layers of natural and/or synthetic materials, each designed for one or more specific purposes, such as gas control, internal drainage, and to support vegetation. The Bibliography lists a number of EPA guidance documents that address cover system function and design, beginning on page 59.

Other Containment System Components

- **Liner systems** are barriers that are typically constructed at the bottom of landfill cells to prevent the migration of contaminants to the environment. Liner systems prevent leachate and gases produced by the landfill from contaminating adjacent soil and groundwater. Liners usually consist of hydraulic barriers fabricated with clay or geomembranes, depending on local geology and environmental requirements. Most old landfills and other waste depositories in the Superfund program do not have liners.

- **Leachate collection systems** control the movement and prevent the buildup of leachate within a containment system. Leachate is produced when water percolates through wastes and carries biological and chemical constituents into the water. These systems typically consist of high hydraulically conductive soil (e.g., sands and gravels) and perforated pipes located between the waste and the bottom liner. Leachate collection systems are typically sloped 1 to 5 percent toward a sump. A pump is used to extract the leachate from the sump. Most old containment systems at Superfund sites do not have leachate collection systems.

- **Gas collection systems** are incorporated into the cover system to control the movement and prevent the buildup of harmful gases within a containment system. Two common types are passive systems and active systems. Passive gas collection systems include a series of vents that extend vertically through the cover. As gas pressure builds within the landfill, gas is forced outward through the vents. Active collection systems use a pump to create negative pressure within the landfill to collect and move gases either vertically or horizontally to a discharge or treatment point. Collection systems can also be designed to recover energy from gases for use in other applications.

Associated Remedial Technologies

Several remedial technologies can be used at a site in conjunction with a cover system remedy. Because groundwater contamination is present at most Superfund sites, the majority of these technologies are for groundwater remediation. The following are some of the more common types of technologies associated with containment systems.

- **Groundwater pump-and-treat systems** typically consist of a number of extraction wells or french drains that collect contaminated groundwater for subsequent treatment above ground. There are a number of additions and variations to a typical groundwater treatment system that can enhance performance or target other media such as soil. These variations can use in situ technologies, such as dual phase extraction, soil vapor extraction, and air sparging, and some ex situ technologies, such as air stripping, carbon adsorption, metals removal, and biological treatment. Whatever the specific groundwater treatment system and media, all collection and treatment systems require piping, utilities, and on-site or off-site treatment systems, in addition to wells and drains.

  The need for and location of such facilities must be considered when developing reuse plans and laying out the golf facility, in order to ensure that the golf facility does not reduce the effectiveness of the remedy. To facilitate operation and maintenance of the remedy components, it is preferable for the golf facility layout to allow for access, which may be needed throughout the life of the systems. Placement of the components should also consider their proximity to public areas, affect on facility aesthetics, and the potential for attracting vandals.

- **Diversion walls** are below-grade structures designed to divert uncontaminated groundwater away from contaminated material or to channel contaminated groundwater. Diversion walls can be grouped into three types: sheet pile, grout, and slurry. Of the three types, slurry walls are used most frequently. They are less costly and have lower permeability than grouted barriers. They are often used in combination with hydraulic controls or extraction and treatment technologies to channel groundwater into a particular area or to enhance containment measures. These structures are also used in conjunction with covers to fully confine a waste area and to prevent water from leaching through the wastes. Groundwater wells are generally used to monitor the effectiveness of the remedy.

  Since diversion walls are below-ground features, they typically will not interfere with golf facility use. However, should a wall or well need repair, it would be preferable if workers are able to access them without significantly hindering the operation of the planned golf facility or damaging the flora, fauna, and water resources in the area. Thus, the EPA project manager should consider the potential impact of the location of these walls on the golf facility. For example, barrier walls can be placed near the edge of a property, or under areas with little or no vegetation. Nevertheless, the implementation of the remedy is EPA's first priority. Although every reasonable attempt should be made to accommodate reuse, it may sometimes be necessary to revise reuse designs to accommodate remedies.

- **Permeable reactive barriers** (PRBs) are both containment and treatment systems for contaminated groundwater. Reactive material is placed in the subsurface in the path of a plume to intercept it. As the groundwater flows through the media, contaminants are destroyed or made insoluble by the reactive material, and treated water flows out the other side of the barrier. PRBs generally have monitoring wells behind them and may also have monitoring wells placed within them to evaluate changes in physical and chemical characteristics over time. Because of sampling activities and the potential need to replace or repair the reactive materials, access to the wall is required until the cleanup is complete.

- **Solidification and stabilization** (S/S) involves modifying the physical or chemical properties of the waste to improve its engineering properties or leaching characteristics, or to decrease its toxicity. Solidification encapsulates contaminants into a solid material of high structural integrity. Stabilization converts waste contaminants into a less soluble, mobile, or toxic form. S/S reagents are typically Portland cement, fly ash, lime, and slag. Some types of waste require solidification or stabilization before being placed in a landfill or covered by an engineered cover system.

S/S can be done either ex situ or in situ. Ex situ processing involves (1) excavation of the contaminated waste; (2) sorting to remove large pieces of debris; (3) mixing with a S/S reagent; and (4) placing the treated material in a permanent disposal location where it is allowed to cure. In situ S/S entails mixing the contaminated material in place using a large mixing auger that injects reagents. Once cured, a protective cover is generally placed over the treated material.

Vitrification, a special type of S/S, is the application of high temperature treatment aimed primarily at reducing the mobility of metals by incorporating them into a vitreous mass. The temperatures required to vitrify soil will also result in the pyrolysis and combustion of organic contaminants. As with most S/S operations, vitrification can be performed both ex situ and in situ.

Remedial Design and Site Issues

This section describes key factors considered during remediation that will influence the effectiveness of the remedy and the redevelopment of a property that has contaminated material or operating waste treatment systems left on site. These factors include managing surface drainage, settlement, stability, the design of foundations and platforms, the provision for utilities, managing gas, and institutional controls.

Presumptive Remedy

The remediation of sites with similar characteristics may be accelerated by using a “presumptive remedy.” A presumptive remedy is based on EPA's experience, which demonstrates that where sites have similar characteristics, those characteristics result in the selection of similar remedies in their RODs. EPA’s approach to presumptive remedies is provided by EPA's Superfund Accelerated Cleanup Model, (SACM). See http://www.epa.gov/superfund/resources/presump/ for additional information concerning presumptive remedies.

EPA’s presumptive remedies allow for containment of waste, where treatment is impracticable, such as at sites with large quantities of heterogenous wastes. For example, the presumptive remedy for source containment at landfill sites includes the following components: a protective cover; source area groundwater control to contain a plume; leachate collection and treatment; landfill gas collection and treatment; and/or institutional controls to supplement engineering controls. An EPA report, "Presumptive Remedy for CERCLA Municipal Landfill Sites,” EPA 540-F-93-035, presents source containment components for municipal landfill sites.

Various types of containment systems are used for the presumptive remedy, depending on the type of contaminants present and other factors. Some of the key factors that affect the design and implementation of the remedies are discussed below.

Grading and Drainage

Water runon and runoff from precipitation can erode the surface layer of a cover system as well as percolate into the cap. Examples of techniques used to manage water flow on cover systems include grading the cap to establish an effective slope, and building drainage channels and swales. Rain water management measures are often incorporated into golf courses as design features. Examples of such measures include steep slopes or swales to direct runoff, tall grass or other vegetation to minimize soil loss, and water detention ponds. A minimum gradient or slope of 2 percent is normally required to facilitate surface drainage. Where differential settlement is anticipated, minimum slopes of 3 to 5 percent are often used to improve storm-water drainage and the operation of the internal drainage system.

In addition to helping to maintain the cover system, surface runon and runoff controls can also be used to maintain water quality and, where possible, protect or enhance aquatic and terrestrial habitats. Storm water can be routed to support aquatic habitat, provide irrigation, or be drained quickly to retention facilities on site. Surface runoff controls may also be used to collect and direct storm water to on-site facilities prior to off-site discharge locations such as wetlands, ponds, lakes, streams, or rivers. On-site storage areas, such as wetlands and ponds may also enhance the aesthetic appeal of the golf course.

Several regulatory programs generally must be complied with when designing runoff controls. Section 404 of the Clean Water Act (CWA) outlines the requirements for dredging and filling activities in waters of the U.S., which includes wetlands, streams, and lakes. Development restrictions and zoning of floodplains are typically the responsibility of local authorities; and the state may have state erosion control and storm-water detention requirements.

The storm-water quality provisions of Sections 402 of the CWA may also apply in some circumstances. These provisions are intended to minimize non-point source pollution.

Settlement

Settlement of a containment system cover is the result of consolidation of both the waste material and the soil underlying the waste. Settlement is attributable to consolidation of soil particles and landfill debris, physical chemical changes from corrosion, and bio-chemical decomposition. Protective covers are subject to general and differential settlement. General settlement occurs when large areas of a site settle at a more-or-less uniform rate. Differential settlement occurs when adjacent areas of a landfill experience large differences in the rate of settlement. The magnitude of settlement depends on a number of factors, including the following:

- Thickness and density of the waste,
- Type of wastes (e.g., construction debris and municipal waste),
- Amount of decomposable materials,
- Leachate, moisture content, and groundwater conditions,
- Weight of the final cover,
- Type of soils located beneath the waste, and
- Stress history (landfill operational history).

Excessive general or differential settlement of the cover system can have the following effects:

- Disruption of surface and internal drainage layers, or gas or leachate collection systems, resulting from changes in the slopes,
- Damage to irrigation systems,
- Pooling of surface water,
- Disruption and damage to golf course features, such as tee and green complexes,
- Slope instability resulting from steepened side slopes,
- Increased permeability of a compacted clay hydraulic barrier layer due to cracking,
- Failure of a geomembrane or other geosynthetic material because of tensile stresses, and
- Failure of cover penetration connections (e.g., gas vent pipe boots).

If pump-and-treat systems are part of the remedy, or if irrigation systems are to be installed, the effect of lowering the water table needs to be considered in the settlement analysis. Lowering the water table will create higher effective stresses in the previously saturated strata. This may result in a greater degree of consolidation of these soils and larger settlement of the landfill cover.

When golf reuse has been selected for a site, it is advantageous to determine the conceptual design and layout of the golf facility prior to the design of closure contours and the completion of the cover layer. The locations of the tee and green complexes will require special consideration because additional fill material will be necessary to elevate these features. Settlement below or immediately adjacent to tee and green complexes can cause severe damage and necessitate costly reconstruction. In some cases, with the proper planning and design, the cover layer can be adjusted during the remediation to accommodate the fill and construction requirements of tee and green complexes or other features of the golf facility, providing EPA does not incur any costs, nor *require* a PRP to incur extra costs, beyond those necessary to ensure protection of human health and the environment, as explained in the discussion on "enhancements" on page 6.

Waste Settlement Analysis. Geotechnical engineers typically estimate settlement potential based on the type, age, and thickness of waste, and the thickness of the landfill cover. However, where there is significant variability of waste placed in a containment system, settlement is often difficult to estimate and should be determined across several sections that are considered representative of the site. These analyses help to determine whether or not adverse impacts are expected as a result of general or differential settlement. If the material underlying the waste is fine-grained soil, such as soft clay, its consolidation will contribute to the overall settlement of the final cover. Traditional settlement analyses, based upon site-specific soil characteristics and loading conditions are used to estimate their settlement.

Settlement Design Considerations. Prior to the placement of a landfill cover, the surface may be cleared of vegetation and compacted with heavy equipment to reduce settlement. Compaction affects only the upper few feet of waste. Resilient materials, such as old tires, will not compact under any amount of rolling. When excessive settlement of either the waste fill or the underlying soil is expected, preloading or dewatering can be used to minimize post-construction settlement. For golf reuse, areas of expected settlement should be identified and avoided or otherwise addressed in the design of the golf course. Consideration should be given to the location of major features, such as tee and green complexes, bunkers, ponds and the irrigation system to avoid damage that would affect the operation and maintenance of the facility, and to construction techniques that can accommodate settlement.

Cover Component Stability

The stability of a landfill cover is controlled by the following factors:

- Properties of the soil underlying the waste,
- Strength characteristics and weight of waste,
- Slope inclination,
- Leachate levels and movements within the landfill,
- Frictional resistance of cover material interfaces, and
- Ability of the cover to freely drain infiltration.

The stability of the interfaces between the various cover system layers normally controls the design of side slopes of a cover system. The stability of these interfaces is assessed by analyzing the frictional resistance between each adjacent layer. Typical interface friction angles between adjacent geosynthetics or between the geosynthetics and adjacent soil range from 8 to 25 degrees. Reinforcement layers can be incorporated into the cover system to help prevent stability problems. Typically, geotextiles or geogrids are used for reinforcement purposes.

The overall stability of the waste fill mass and underlying soil is generally considered. The geotechnical characteristics of waste materials are generally difficult to determine and are highly variable. These characteristics are usually estimated based on experience with actual cases of failure or cases where large deformations in waste have occurred. They can also be conservatively estimated by observing existing waste slopes to determine the strength parameters. Strength parameters used for the soil underlying the waste are usually determined through field sampling and laboratory testing. Seismic considerations should also be addressed where applicable.

Foundation Systems

Foundation systems support the walls, floors, and roof of structures. Ideally, planners should avoid placing significant structures such as clubhouses or large maintenance buildings directly on a landfill or other waste containment area. If a building is to be placed on a landfill surface, it is important to consider the protection of the final cover system and the

Construction of the foundation for the golf tees for the driving range built on top of the Kane & Lombard Street Superfund site in Baltimore, Maryland.

prevention of damage to the building or creation of unsafe conditions that may result from general or differential settlement. Although the foundation systems used at sites containing contaminated waste are similar to those used in general construction, their use on a containment system require special considerations.

Foundation systems can be classified as either deep or shallow. Deep foundations are generally used when the ground immediately below the surface does not have sufficient strength to support the proposed structure, and it would be too costly to increase its strength. Deep foundations typically consist of pilings that are driven or drilled into the subsurface in order to reach a geologic material capable of supporting the proposed structure. Pilings may be made of steel I-beams, precast reinforced concrete, poured in place concrete, and caissons (metal casings set at the appropriate depth and subsequently filled with concrete).

Deep Foundations are Useful in the Following Situations:

- The site has the potential for extensive settlement, which makes a shallow foundation inappropriate
- The containment system has an unlined bottom
- The waste material can be driven or drilled through
- There is no potential of intercepting an uncontaminated aquifer

Because many closed-in-place containment areas are expected to undergo settlement, deep foundations are an effective way of protecting structures placed on them. Pilings may be driven or drilled into a containment system that has an unlined bottom. Deep foundation systems should be placed prior to construction of a landfill cover system. If deep foundation systems are used over a containment area, they will have to be engineered into the cover system. This process involves the installation of engineered seals (sometimes called boots) where the foundation penetrates the cover. The boots need to be attached to both the cover system’s hydraulic barrier layer and the piling to prevent water from infiltrating into the contaminated material.

Shallow foundations can be divided into two broad categories—footing and slab. A footing foundation is one designed to support the outside walls or vertical support columns of a building. While they can be placed directly into some contaminated materials, this practice is generally avoided out of concerns for the health and safety of the construction crew and future maintenance workers. More commonly, footing foundations are placed in clean fill above the cover of the containment system. When differential settlement is a concern, one design alternative for one and two story buildings is tilt-up wall construction. In this type of construction both the wall and the footing are broken up into discrete sections that allow for some differential settlement without putting stresses across the entire building. Control and leveling joints are used to offset the settlement of individual wall sections.

Slab foundations are usually reinforced concrete placed directly on the ground. One approach to using slabs on a site that has potential for differential settlement is to build the slab in separate sections and install cable linkages between them and precast ports near each section for pressure grouting. This arrangement allows for differential settlement of each slab, and gives the building owner the ability to separately level each section by pressure grouting into the areas that have settled. Slab foundations can also be stiffened by incorporating beams into their construction. This technique allows the slabs to bear more differential settling than regular slabs. Slab foundations can be engineered to accommodate a variety of situations, depending upon the type of waste containment system and budget.

Built Up Grades Can Provide the Following:

- An uncontaminated space for foundations, utility corridors, and piping for irrigation or gas ventilation systems
- Protection of the cover and utilities from freeze/thaw cycles
- Protection of the cover and utilities from floods
- Additional compaction of waste materials

Gas Management

Depending on the waste composition, containment sites have the potential to generate gas, which, if not properly controlled, could damage the cover system, create fire or explosion hazards within buildings, stress vegetation, cause odors, and pose other health or safety hazards. Although gas management is important for all sites, added emphasis and caution are required at sites containing structures with enclosed spaces that will be used by the public.

The quantity, rate, and type of gas generated are primarily dependent on the composition, age, volume, and moisture conditions of the waste. Gases from municipal landfills generally contain approximately 50 percent methane, 40 percent carbon monoxide and 10 percent other substances, including nitrogen and sulfur compounds. Gases from mixed waste municipal landfills and industrial landfills may also contain volatile organic compounds.

There are two aspects to gas control: a gas collection system that is usually built into the containment system and gas protection incorporated into the buildings developed on or near the containment system.

Gas collection systems. Constructed as part of the cover system, gas collection systems are designed to be either passive or active. A passive system allows the gas to exit the collection system without mechanical assistance, whereas an active system uses blowers to create a vacuum within the landfill and extract gases. Depending on the potential impacts of the landfill gas and local regulatory criteria, gases are either dispersed into the atmosphere or collected and treated.

Some closed landfills will have a well system that was installed during the operation of the landfill. Well systems typically consist of a series of gas extraction wells that penetrate to near the bottom of the waste. Well systems are recommended for landfills or portions of landfills that exceed 12 meters (40 feet) in depth. The vent borehole diameter may range from 0.3 to 1 meter (1 to 3 feet). The components of extraction wells are usually similar to those of standard groundwater monitoring wells (i.e., riser, screen, gravel pack). If a containment system does not include a well or gas collection system, the following are some options for gas control:

- **Continuous Blanket Systems**. EPA recommends that a continuous blanket system to collect gas have a minimum of 300 mm (12 inches) of granular fill or an equivalent geosynthetic material located below the hydraulic barrier layer. Vertical outlet pipes transport the collected gases from beneath the landfill cover system to the atmosphere or to a treatment facility.

- **Shallow Trench Systems**. For landfills where the waste materials are relatively shallow (less than 12 m [40 feet] deep), collection trenches may be used. The trenches are usually excavated about 0.5 to 1 m (1.5 to 3 feet) into the waste and lined with a geotextile. Perforated pipe is then installed and the trenches are filled with gravel.

- **Monitoring Probes**. Gas monitoring probes are used in conjunction with both active and passive collection systems to detect landfill gases that may migrate off-site. Usually, the regulatory compliance point is located at the property boundary. Probes are typically placed around the landfill perimeter. A typical monitoring probe consists of a small-diameter slotted pipe in a borehole that extends to an elevation corresponding with the bottom of the waste or to the water table, whichever is shallower.

When designing a gas collection system in an area that will be used by the public, particular attention should be given to the types and concentration levels of the gases and their potential impacts on health and safety. Vents, collection wells, piping, discharge points, and treatment systems can be placed in areas that will not interfere with planned or prospective uses, where the effects of noise and odor are minimized, and where they are less likely to be accessible to potential trespassers and vandals. For golf reuse, the engineering of the collection systems, vent locations and other components should be coordinated with the design of the golf course to avoid the playing areas of the course or other locations frequented by workers and golfers.

Structures. If structures are to be placed over containment areas that generate gas, they should be designed with their own gas management systems and not depend solely on the cover's gas management system. The following are examples of gas protection techniques for buildings:

- Engineer an air space to allow for gas detection and venting, as well as to facilitate inspection and maintenance of the cover.
- Place gas detectors in closed structures to warn of potential gas buildup.
- Install vent fans to remove methane from below structures and in crawl spaces.

- Place an impermeable (gas resistant) geomembrane or other hydraulic/gas barrier under the structure or within the building's floors. This is especially important for sites likely to experience settlement that may disrupt the cover. Construct floor slabs with convex bottoms to prevent methane from pooling below the structure.

- Ensure that the design of utilities does not allow for gas migration along utility conduits. One approach is to attach utility service entrances to the outside wall of the structure so they do not penetrate the floor slab, which may create a pathway for gas entry.

Utilities

Most ancillary facilities require utilities, such as sanitary sewers, potable water, natural gas, electricity, and telecommunications. Although most utilities are installed underground, some, such as electricity and telecommunication lines can be above ground. When overhead facilities are used, they should be not be routed through or adjacent to the playing areas. Utilities can impact the effectiveness of the containment system in the following ways:

- A utility line can become a conduit for gas migration.
- A utility structure that penetrates the cover system can serve as a conduit for water infiltration into the waste.
- If the utility is located within or below the cover system, repair or upgrade work would also require excavation into the cover and contaminated material.
- If the utility is located within or below the cover system, liquids leaked from a sewer or water supply line can increase the quantity of leachate generated. Leakage from a sanitary sewer located above a cover system's hydraulic barrier layer might be captured by the internal drainage system and cause excessive bio-fouling of drainage media.
- Differential settlement of the waste can result in damage to the utility.

The EPA site manager may have a great deal of discretion in deciding how containment systems are built and where they are placed on the site. For example, clean "utility corridors" can be created by placing the piping and other components into oversized trenches which are then backfilled with uncontaminated, or "clean" soil. The additional width and depth of the trenches limits the possibility that waste will be encountered or the cover system will be damaged during future excavations.

Utility corridors can often be placed in uncontaminated materials by adding sufficient clean fill above the contaminated material. When this technique is used, a good safety measure is to place visible barriers, such as colored soil or brightly colored synthetic materials between the contaminated material and the clean fill to act as permanent markers for future workers. However, with proper precautions, such as using a contractor who is certified to work with hazardous waste, the utilities can be installed directly in the contaminated area. A contractor or property owner who does this type of installation is required to obtain authorization from EPA to excavate into the materials, as well as obtain EPA approval of the plan for the proper management of any contaminated material.

When used in areas that will experience differential settlement, piping should be designed to accommodate some movement by using features such as ductile materials and flexible connections. For pressurized water and gas systems, automatic monitoring devices and shut-offs may be used to prevent large uncontrolled releases. Gravity sewers and other non-pressurized systems should also be designed for easy monitoring. For example, double-walled piping equipped with an integrated leak detection system may be used. Another monitoring technique is to line the utility trench with a geomembrane prior to installing the piping and sloping the trench to direct the flow to monitoring sumps. The sumps could be periodically checked for liquids. The need for and type of monitoring system would be determined based on cost, implementability, performance, maintenance, and the perceived risk of leaks.

Institutional Controls

Institutional controls are non-engineered instruments, such as administrative and legal controls, that help to minimize the potential for human exposure to contamination and/or protect the integrity of the remedy. Institutional controls are often used to supplement engineering controls when residual contamination prevents the site from supporting unlimited use and unrestricted exposure. Institutional controls can be used to accomplish objectives such as restricting the use of a property, preventing or limiting drilling of wells or extracting groundwater, or restricting access. A number of administrative or legal mechanisms can be employed to implement the necessary restrictions, such as easements, zoning rules, deed notices, permits and orders. Institutional controls are implemented during or immediately following construction of the engineered remedy and should be maintained as long as needed to prevent exposure or protect the remedy.

Golf course designers should be aware of the need for institutional controls as early in the development process as possible, such as during the feasibility study stage. Site managers and golf course designers should work closely with state officials, tribal leaders, PRPs, other federal agencies, and local governments, as appropriate, to ensure that institutional controls are implemented, maintained, and enforced. Section 4 contains a more detailed discussion of the role of institutional controls at golf courses.

For an explanation of EPA's policy on the proper use of institutional controls at Superfund sites, see *Institutional controls: A Site Manager's Guide to Identifying, Evaluating, and Selecting Institutional Controls at Superfund and RCRA Corrective Action Cleanups*, EPA OSWER Directive No. 9355.0-74S-P, EPA-540-F-00-005, September 2000. **http://www.epa.gov/superfund/action/ic/index.htm**

Section 4. Operation and Maintenance

Operation and maintenance (O&M) activities can be divided into those related to the golf facility and those related to O&M of the hazardous waste containment and control systems. The golf facility developer or property owner is responsible for O&M of the golf facility. Once the O&M period for the remedy begins, the state or PRP is responsible for O&M related to the remediation. For Fund-financed remedial actions involving treatment or other measures to restore groundwater or surface water quality, the Fund will continue to pay for the operation of such treatment or measures for a period up to ten years.

Regardless of who is responsible for O&M, the necessary activities related to the remedy may be conducted by the operator through an agreement, although the state, PRP, or EPA may remain responsible for ensuring that the remedy continues to protect human health and the environment. Usually, when a golf facility operator performs O&M, the overall costs will be lower, since golf facility personnel are already on-site. However, some training may be necessary.

O&M measures related to waste containment and control are initiated after the remedy has been constructed in accordance with the ROD and is determined to be operational and functional (O&F) based on state and Federal agreement. For Superfund-lead sites, remedies are considered operational and functional either one year after construction is complete or when the remedy is functioning properly and performing as designed, whichever is earlier. Additional information on O&M for a Superfund site is available in EPA publication EPA 540-F-01-004, "Operation and Maintenance in the Superfund Program."

Cleanup Remedy O&M

Typical remedy components requiring long-term O&M measures include landfill covers and liners; gas extraction, treatment, and monitoring systems; water collection, treatment, and monitoring systems; and permeable reactive barriers. It is preferable for the remedy and reuse plans to allow for continual access necessary for inspection and repair of these components and sampling. O&M monitoring includes five activities.

Inspection. Routine inspections are performed on a regular basis, with the frequency of inspections dependent on the complexity of the remedial measures. Non-routine inspections are performed after unusual events such as earthquakes or large storms. Typically, inspectors check for pooling water, erosion, settling, and burrowing animals, dead or dying vegetation (which may be caused by methane), among other items. They also conduct periodic topographic surveys to measure the rate of movement or settlement.

Sampling and analysis. Sampling and analysis is conducted to monitor groundwater and surface water quality, leachate formation, and gas release concentrations. Sampling and analysis will typically include the collection and chemical analysis of gas, air, and water samples from wells, probes and other means. The frequency of sample collection may vary from daily to annually.

Routine maintenance and small repairs. Routine maintenance may consist of simple activities such as mowing of a cover or the repair of perimeter fencing. On sites that have operating treatment plants, routine maintenance will be more complex and may require a full- or part-time plant operator. Typical activities include operating groundwater and gas treatment systems; repair of rainwater collection and diversion systems; repair of erosion scarps; mowing and maintenance of landfill cover systems; and repairs due to vandalism.

Reporting. Operation and maintenance reports are typically written and submitted to regulatory authorities after both routine and non-routine inspections. The reports contain information on the general condition of the remedial measures, test results from samples collected, and operational data from treatment processes (e.g., groundwater extraction rate, gas flow rate, etc.).

Five-year reviews. In addition to the requirements for annual and special inspections, EPA conducts an in-depth review of the remedy at least every 5 years for any site where the remedial action resulted in hazardous substances, pollutants, or contaminants remaining on site above action levels that would allow for unlimited and unrestricted use. The five-year review generally consists of two components: an analysis of whether the remedy is still protecting human health and the environment, and a list of additional maintenance activities that need to be performed to ensure continued protectiveness, including the identity of the parties responsible for those activities.

The results of these reviews can be used to modify operating plans and golf facility operating plans as needed. On occasion, the results of a five-year review may indicate the need for significant revisions to the remedy, such as the placement of additional monitoring wells, or the replacement of a passive gas venting system with an active one.

Five-year reviews can be performed by EPA or the lead agency for a site, but EPA remains responsible for determining the protectiveness of the remedy. For additional information concerning five-year reviews, see EPA Publication 540/R-98/050, "Comprehensive Five-year Review Guidance."

Golf Course O&M

Golf courses generally establish a comprehensive and thorough O&M plan that specifies the necessary tasks and identifies the party responsible for them. The following is a list of typical O&M tasks performed at a golf facility:

- Regularly scheduled mowing, irrigation, fertilization, and weed control of tee and green complexes, fairway and rough areas, and out-of-play vegetation;
- Maintenance of parking lots, golf cart paths, clubhouse and O&M facilities;
- Repair, replacement, or upgrading of irrigation equipment;
- Periodic, specialized maintenance or renovation of tee and green complexes, and fairway and rough areas;
- Maintenance of storm-water drainage features and facilities; and
- Planting trees, turfgrass, and other vegetation, and improving their environment.

At locations where the golf facility will be placed on a containment area, the O&M plan may also address special considerations related to the hazardous waste. Often, the O&M activities for some remedy components will overlap with typical golf course O&M. For example, mowing a containment system cover, maintaining perimeter fencing, and maintenance of storm-water drainage features and facilities may be common to both activities. Other O&M activities will be specific to a remedy and are not likely to be found at most golf courses in the U.S. For example, groundwater sampling or operating gas or water collection and treatment systems. The developer and remedial teams need to agree on a plan to do this work and have it paid for. Some of the special consideration are listed below.

Monitoring for explosive gases. As discussed in Section 3, containment areas can produce harmful gases. Nearby structures should be monitored to ensure that gas is not present.

Increased monitoring of subsurface moisture conditions. The cover design may require restrictions on the amount of irrigation that can take place. Monitoring of subsurface moisture conditions may be required to detect the infiltration of water into the underlying hazardous waste.

More frequent repairs due to settling. Because some sites tend to settle with time, as described in Section 3, extra monitoring of parking and playing areas is needed, and special precautions should be taken for buildings, and other structures placed on containment areas.

Repair of irrigation systems. Special procedures may be required for replacing sprinkler heads and other subsurface equipment to ensure containment system drainage and barrier layers are not disturbed. Automatic monitoring and shut-off devices should be used to prevent large uncontrolled releases of water due to unforeseen damage to the system.

Repair of golf course features. Special procedures may be required for the repair of tee and green complexes, bunkers and other golf course features to ensure landfill drainage and barrier layers are not disturbed.

Fertilization and pest control. Because of the heightened sensitivity to protection of the environment, the use of environmentally friendly methods of fertilization and pest control (IPM) may be encouraged to prevent the use of undesirable chemicals on the site.

Erosion repairs. To prevent damage to protective covers and other remediation components, rapid repair of eroded areas must be performed. Erosion repairs will typically consist of backfilling erosion scarps and reseeding. Temporary, degradable rolled erosion control products are sometimes used to protect repaired areas until vegetation has been reestablished. Areas with persistent erosion problems may need to be redesigned to eliminate the erosion problem.

Renovations. The O&M plan for the course should address the need for the following types of activities: rebuilding greens, bunkers, and tees; replacement or addition of trees and vegetation; expansion, repair, and maintenance of irrigation systems; installation of subsurface drainage structures; construction of buildings and other facilities; planting of trees and other deep rooted vegetation; and installation and maintenance of underground utility lines.

Worker Safety. The Occupation Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response (HAZWOPER) standard (29 CFR 1910.120/29 CFR 1926.65) regulates worker safety and training requirements at hazardous waste sites during construction and operation when there is potential contact with the hazardous waste. These regulations do not apply to golf facility workers who do not perform O&M activities specifically related to the remediation process that would cause them to have direct contact with the hazardous waste. However, the O&M plan for the golf facility should alert workers to potential dangers associated with the remediation controls that have been implemented at the site and inform them about what response measures would be appropriate in the event a dangerous situation related to the hazardous waste arises. The HAZWOPER regulations do apply to O&M workers responsible for operation of the remediation activities associated with the hazardous waste cleanup activities.

While golf facility maintenance workers not directly exposed to hazardous waste may not be required to have the formalized training described in the HAZWOPER regulations, other regulations pertaining to worker safety outlined in 29 CFR 1910 related to activities such as pesticide and fertilizer application, and operation of equipment will apply. Applicable training in these areas must be provided to golf facility workers, in order to ensure worker safety and to comply with the regulations.

The developer/owner will be responsible for O&M of the golf facility. O&M costs will probably be higher than for a typical golf facility because of the above precautions. The O&M plan should outline an approval process for renovation projects such as those outlined above. Regulatory approval will likely be required for significant renovations.

Although many of these activities may be conducted by the golf course operator, the O&M related to the remedy will ultimately be the responsibility of the state or PRP, regardless of whether a business venture succeeds or fails. The state or PRP is legally responsible to ensure that contamination does not escape from the site and endanger human health or the environment. To assist the state or PRP in exercising this responsibility, they may develop contingency plans for ensuring that hazardous waste remediation and control measures continue to be effective in the event the golf facility fails as a business venture. Continuing maintenance of the remedy may require the removal of some or all of the golf facility components.

Institutional Controls

Remedies often incorporate institutional controls to prohibit or restrict certain activities and land uses that may jeopardize the protectiveness of the remedy. Restricted activities can include the drilling of wells, limiting the use of groundwater, excavating below a specified depth, and restricting the placement of buildings on a site. Public access to certain parts of a site, such as areas containing gas vents, may also be restricted to authorized personnel. These controls are implemented through land-use regulations imposed by local governments; property law measures such as easements and covenants that restrict future land or resource use; enforcement devices such as permits, orders, and consent decrees; and informational devices such as deed notices that inform prospective purchasers of residual on-site contamination.

Because of their importance in restricting future land uses to ensure the protectiveness and integrity of the remedy and in defining long-term compliance needs, any institutional controls needed should be identified and evaluated as early in the remedy selection process as possible. Institutional controls should be evaluated as rigorously as other remedial alternatives; their objectives clearly identified in the decision documents; and developed through early coordination with state and local governments and other stakeholders. If revisions or additions to institutional controls constitute a substantial change to the remedy documented in the ROD, stakeholders must be informed.

During remedy selection and design a PRP can address how to accommodate a potential future need to excavate into contaminated materials and how to ensure that institutional controls are maintained well into the future, especially when properties change hands. The following are three common considerations for the effective use of institutional controls at sites being reused as golf courses.

- **Excavating into Contaminated Materials**. A site owner who intends to excavate into a containment system generally must obtain prior written approval from the EPA Region and use a contractor certified to handle hazardous materials if the materials are classified as a RCRA hazardous waste, or if the requirement is specified in the remedy. This requirement could mean costly delays for the developer. The process can be simplified by including excavation procedures in the institutional controls and other site agreements. This approach could preclude the need for special approvals, as long as the contractor follows the established procedures and notifies EPA or a state regulatory authority. Another useful approach to ensuring that future excavations at a site do not disturb the containment system is to require the PRP or property owner to file a survey plot recording the type, location, and quantity of contained waste, and as-built drawings with the clerk of the local court and with the local recorder's office.

- **Long-Term Compliance with Institutional Controls.** Institutional controls are often incorporated into consent decrees and other negotiated enforcement documents. One potential pitfall of this approach is that certain enforcement documents may only be binding on the signatories and may not "run with the land." Although the responsible parties are still ultimately responsible for compliance with the institutional controls, future owners of the property may not be bound to the terms of the consent decree nor have notice of the restrictions. It may be possible to avoid this potential problem by requiring signatories of an enforcement document to implement more long-term institutional controls, such as information devices or proprietary controls, and to record the relevant documents with the appropriate local officials.

- **Adequate Monitoring of Institutional Controls.** One of the most critical post-implementation aspects of ensuring the long-term effectiveness of institutional controls is rigorous periodic monitoring. It is essential for there to be a process that routinely and critically evaluates the institutional controls to determine (a) whether the mechanism remains in place, and (b) whether the institutional controls are providing the protection required by the remedy.

In developing remedial alternatives that include institutional controls, EPA may also consider the capability and resolve of local authorities or private sector interests to implement the institutional control program. At the Bunker Hill site in Kellogg, Idaho, a system of flexible institutional controls is operated by existing local administrative structures and programs that are consistent across all jurisdictions affected by the site. Using this strategy, the Idaho Legislature amended the Environmental Health Code to include specific containment management regulations and performance standards. With the state legislature's approval, the local jurisdictions were given the authority to govern all excavation, building, development, grading, and renovation at the site. Furthermore, the local jurisdiction was made responsible for educating the community about the redevelopment program.

Section 5. Golf Facility Case Studies

This Section describes four projects where golf courses have been developed on remediated properties. Although these projects represent a wide range of sites, pollution problems, and golf facility configurations, they are not exhaustive of all circumstances that occur at Superfund sites. Nevertheless, they demonstrate how remediation and redevelopment efforts may complement each other. The discussion for each site includes a brief background of the site and its contamination, key factors considered during remediation that were important to the redevelopment, and the redevelopment plan. The four projects are listed below.

- **Old Works Golf Facility, Anaconda, Montana:** This 250-acre, altitude-adjusted par 72 course is one of two Jack Nicklaus Signature courses in Montana. The course's irrigation and drainage system is designed to prevent water infiltration into subsurface contaminated materials. The golf course layout takes advantage of the natural landscape and features left from the old smelter. The course's bunkers contain tons of inert black slag material left by the copper smelting process.

- **Harborside International Golf Center, Chicago, Illinois:** This center features a matched pair of 7,150 yard, 18 hole championship golf courses, a 58-acre practice facility, and a Golf Academy. It is situated on a 450-acre former municipal landfill that contains sanitary and construction debris. The development of the facility contributed to other environmental and community goals, such as the development or protection of wetlands. Developers took advantage of available materials, such as treated sludge, for use as fill and for the growing medium for turfgrass.

- **McColl Superfund Site, Fullerton, California:** This 22-acre site has been integrated into an adjacent golf course. It was built over 12 unlined pits containing refinery wastes and is adjacent to residences and a regional park. The project involved building subsurface barrier walls, a multi-layered cap over the pits, a gas collection and treatment system, and groundwater monitoring equipment.

- **Widow's Walk Golf Course, Scituate, Massachusetts:** This 120-acre site is both a golf course and a corridor of mixed habitats for plants and animals. Prior to remediation, the site included a mined-out sand and gravel quarry used as an illegal dump. To support a variety of plants and animals, the golf course design incorporated a combination of diverse habitats, such as open water ponds, wetlands, vegetated streams, wooded areas, open grassy areas, and vernal pools. The design also incorporated environmentally-friendly golf course management features that minimize the use of fertilizers and herbicides, conserve water, and protect groundwater quality.

Additional information on these sites is contained in publications listed in the Bibliography.

Old Works Golf Facility – Anaconda, Montana [3]

Anaconda site at the early stages of the remediation

Site History:
Almost 100 years of mining and smelting activity left behind hundreds of acres of waste. Mine tailings, slag piles, and rubble piles from the long abandoned Old Works buildings lay scattered around the site. In 1977, the Atlantic Richfield Company (ARCO) purchased the Anaconda Company with the intention of continuing mining operations, but shortly thereafter ceased operations at the site. Nevertheless, ARCO inherited the responsibility of cleaning up more than 100 years of pollution. In 1983, the property was added to the National Priorities List, (NPL), EPA's list of sites needing cleanup.

As a result of the mining operations, the soil contained elevated concentrations of arsenic, lead, and copper. Scattered throughout the site were piles of rubble and garbage. The mining operations had virtually decimated all natural vegetation and wildlife, and the site looked like a moonscape. Furnace slag and tailings were left in the flood plain of Warm Springs Creek, which runs through the course site. One of the major concerns was erosion of contaminated soil into the nearby Warm Springs Creek during storm runoff. The contaminated soil also was a potential source of contamination of groundwater and air pollution. The small particulate matter from the contaminated soil could become airborne, thereby spreading the contaminants.

Remedy and Reuse:
ARCO faced the choice of either removing tons of waste materials from the property or taking other remedial actions. ARCO conducted studies and consulted with the community to develop the most appropriate solution. ARCO also consulted with EPA, Montana Department of Health and Environmental Sciences, U.S. Department of Justice, U.S. Fish and Wildlife Service, Anaconda/Deer Lodge Golf Course Authority, and Montana Department of Natural Resources.

The plan was to transform the Superfund site into a top-notch golfing facility for the town of Anaconda and Deer Lodge County. Many features of the golf course were designed in light of the requirements to minimize potential exposure to materials left on site; to protect Warm Spring Creek by controlling runoff from the golf course and surrounding areas; to preserve historic

[3] Love, Bill. 1999. *An Environmental Approach to Golf Course Development.* American Society of Golf Course Architects.

features of the Old Works Historic District; and to implement long term monitoring and maintenance of the remedy and O&M of the golf facility.

Construction began in 1994 and the Old Works Golf Course opened in 1997. During construction, the contractors moved and graded about 600,000 cubic yards of material, built three sedimentation ponds to control runoff from north of the course, and built two golf course lakes which collect and control storm-water runoff from the sedimentation ponds. The lakes also serves as a water storage reservoir for the irrigation system.

Photo: Canyon Publications, courtesy of Old Works Golf Course

Black slag was used in the bottoms of the bunkers and 70 acres of grass was planted

Initially, Old Works was to be a desert links-style course with green ribbons of grass flowing through the badlands. However, EPA believed that more of the property needed to be capped and planted with grass. Approximately 70 acres were planted with grass and other native vegetation. Other key features of the project include:

- Some of the fairway areas were routed over contaminated soil. These areas were covered with 2 inches of lime rock and 16 inches of clay soil. This cover was then covered with 6 to 8 inches of a loamy sand soil, which is the growth medium for the turfgrass. The total cap is 18 to 23 inches thick.
- EPA standards required that the capped areas be irrigated and drained. The irrigation system was designed to provide water and keep the clay cap moist so that it would not dry out and crack. A subsurface drainage system was installed to prevent contamination of the groundwater. The system captures the excess irrigation and storm water and returns it to one of two irrigation ponds lined with a protective neoprene material.
- To prevent storm and irrigation water from making contact with the capped waste materials, a complex subsurface drainage system is connected to all the irrigation mainline drains and blow-offs. This arrangement protects the clay cap in the event of an irrigation pipeline break.
- To protect Warm Springs Creek from excessive water flows resulting from potential irrigation failures at the four holes that border the creek, all lateral lines along these holes were fitted with flow sensors and shut-off valves that automatically shut valves in the event of a break.

Special Golf Course Features:

The Old Works Golf Course in Anaconda, Montana is one of two Jack Nicklaus Signature courses in Montana. The altitude adjusted par 72 course plays through 250 acres and can be stretched to 7,581 yards. The complete practice facility includes a range and three practice holes. The golf course routing took advantage of the natural landscape and features left from the old smelter.

- Several holes on the front nine play along stone smelting ovens, flues, and brick walls. Four holes are routed to take strategic advantage of Warm Springs Creek.
- The course's bunkers are unique. Tons of inert black slag left by the copper smelting process were used in the bottoms of the bunkers. The slag met all requirements for drainage and playability and provided visually stunning effects.
- Native area trees and other plants were planted on what had been a virtual moonscape for nearly 100 years. In addition to the 400 trees planted during construction, the course adds new plant material every year.
- A historic hiking trail now winds its way around the course. The trail highlights Anaconda’s smelting heritage and gives hikers an insight into copper mining techniques of years past.

Photo: ARCO

Hikers walk along a trail that showcases artifacts from the former smelting operations. The trail was built on the Superfund site and surrounds a golf course designed by golf great Jack Nicklaus.

Lessons:

- Golf course design and construction can be completely integrated with remediation efforts.
- The use of indigenous materials can save substantial sums of money as well as provide unique features for a golf facility.
- Historic features at a site can provide unique attractions that make the play more exciting.

Harborside International Golf Center, Chicago, Illinois [4]

Site History:

The site was originally used for disposal of the City of Chicago's municipal solid waste. Later it was used to dispose of incinerator ash and wastewater sludge. In 1991, the Illinois International Port District was faced with a requirement calling for the closing of a 450-acre solid waste landfill that could not be used for industrial, commercial, or residential development. About 200 acres of the site contained a partially-closed sanitary landfill and a 250-acre parcel was being used as a construction debris landfill. EPA required that the sanitary landfill portion be covered with an impervious clay cap and vegetated.

The Port District, seeking a productive use for the site, elected to establish a golf center. Because the site is in the industrial south side of Chicago, the local economy would not support the expense of converting it into a golf facility. However, it was thought that if the center was a "world-class" facility it would attract enough golfers to make the project worthwhile. Fortunately, the site is near I-94, I-57, and I-80, which carry approximately 300,000 cars per day. The planners anticipated that the combination of good access and a good facility would attract sufficient business to make the golf facility economically viable.

Photo: Mike Kemee, Golfoto, Inc.

Completed Course at the Harbor International Golf Center

The Harborside International Golf Center features a matched pair of 7,150-yard, 18-hole championship golf courses and a 58-acre practice facility, including a Golf Academy situated on 450 acres of sanitary and construction debris landfills. Provisions were made for a three-hole practice course. The golf course, which was built between 1992 and 1995, is a daily-fee facility. Although the final cost approached $30 million, the Port District does not have any taxing or bonding authority and had to finance the project through conventional means.

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4 Love, Bill. 1999. *An Environmental Approach to Golf Course Development.* American Society of Golf Course Architects.

Construction of the Harbor International Golf Center

Remedy and Reuse:

Several factors complicated the redevelopment of the site. First, it was devoid of topsoil. The treated sludge, which was the only available cover material, had to be brought to the site at a rate of 250,000 cubic yards per year for 3 years until an alternate disposal site could be found. The deliveries were incorporated into the delivery schedule for the construction site. Second, the 250-acre construction debris portion of the site was about 30 feet lower than the rest of the site and wrapped around the northern and western sides of Lake Calumet, an 800-acre lake which connects to Lake Michigan via the Calumet River. Because this area contained non-organic, non-hazardous material, such as broken concrete and demolished buildings, an impervious cap was not required. Third, sludge could not be placed within a 300-foot buffer zone around the Lake Calumet shoreline. Fourth, three low-grade wetlands that had been formed in depressions of old fill operations were relocated to the upper section of Lake Calumet and upgraded. Several unique design features were used to address these issues.

Special Golf Course Features:

Clay Cover. Over 550,000 cubic yards of stiff blue clay for the cap was excavated with backhoes and large off-road trucks from the shallow north end of Lake Calumet. The excavation cleared the way for a future marina. Sections of the lake were sealed off and drained. Fish were caught in nets and returned to the open water. The clay was placed in three compacted 8-inch lifts over the shaped sludge to form the 2-foot landfill cap. The design specified that a 2-foot layer of sludge be placed over the clay cap of the 200-acre landfill.

Fairways, greens, and contoured bunkers. These features were crafted in a pioneering use of wastewater biosolids carefully blended with other locally available materials. The solids were installed in a complex layering process to form a golf course on the previously flat topography. The result is a sweeping links-style facility reminiscent of Scottish seaside courses with trees that have shallow roots not likely to interfere with the underlying clay cap.

Irrigation system. Though extensive, the golf course irrigation system makes frugal use of water. The irrigation water is drawn from Lake Michigan in quantities that are regulated by a multi-state commission. Drainage and irrigation systems were carefully designed to protect the integrity of the clay cap. They include sensors and controls to manage storm-water runoff and a special pump station to draw irrigation water from the lake while protecting against Zebra Mussel infestation.

Lake Excavation. The first consideration in excavating the lake was protection and improvement of wildlife habitats. Chicago and Cook County have set aside vast tracts of land for parks and forest preserves. Since the area is part of the northern flyway, lake excavation was suspended during migration periods. The Illinois Department of Fish and Wildlife staff culled the desirable game fish from the undesirable rough fish when the sections were drained.

Rainwater Management. The design called for containing all water runoff within the site. The water was discharged to sanitary inlets into the Metropolitan Wastewater Reclamation District's sewer system. However, the sewer system inlet could only accept amounts less than that resulting from a 5-year storm event. The golf course architect and the engineer collaborated in the design of an elaborate drainage and collection system that collects all site drainage and stores it at seven dry retention locations within the site, until it can be released at a deliberate rate back to a sewage treatment plant for processing.

Wetland Mitigation. While the relocation and upgrading of the three small, low-grade wetlands was not necessary for the construction of the golf course, it was done to improve the overall ecosystem of the area. An 8.5-acre peninsula was created in the lake. To offset the filling of this section of the lake, an equal area was excavated in another section to a depth sufficient for fish to survive through the winter.

Protecting Existing Wetlands. The existing wetland sections in the northern-most reach of the lake was adjacent to hole numbers 16, 17, and 18 on one of the courses. Because these wetland areas are emergent, it was especially important to protect them. Several features were incorporated into the golf course to protect them while maintaining an aesthetic landscape. For example, a buffer was created at some points between the course and the shoreline, and some portions of the fairway were raised 8 to 10 feet to allow the incorporation of drainage basins to prevent storm water from flowing into the lake.

Turfgrass Growing Medium. Perhaps the biggest dilemma from the outset was to grow turfgrass on a 450-acre site that is completely devoid of topsoil or other adequate growing medium. The solution was found in the very item that was being disposed of on the site. Every year the Metropolitan Wastewater Reclamation District trucked 250,000 cubic yards of sludge to the site. Although sludge, the end product of the sewage treatment process, is very organic in nature, it is not by itself, a good growing medium because it has high levels of fats and salts. Because of these properties, sludge draws water out of plants and will not readily saturate. To help remedy this, a 6- to 8-inch layer of sand was placed over the fairway. This tapered to 4 inches in the roughs and 2 inches on the mounds in the outer roughs. During the construction of the trenches for the extensive underground irrigation network and drain tiles, enough sludge was excavated to ensure that an adequate amount of organic material was present in the sand layer after final raking. In fact, the grass flourished with virtually no additional fertilizer.

Lessons:

- The development of a golf facility can be integrated with other environmental and community goals, such as the development or protection of wetlands.
- Features of a golf course can be designed to protect nearby surface waters from runoff.
- Cooperation and consultation with other state, federal and local agencies helped to define the ecological issues and to formulate creative solutions that improve the overall ecosystem in the area . (The Illinois Department of Fish and Wildlife, Illinois Environmental Protection Agency, and the U.S. Army Corps of Engineers were especially helpful).
- Through creative engineering, materials available on site can be used to create a medium in which to grow turfgrass and to develop golf course design features.

McColl Superfund Site, Fullerton, California

Site History:

From 1942 to 1946, petroleum companies dumped refinery waste into 12 unlined pits on the 22-acre site. During the expansion of Orange County communities in the 1960s and 1970s, homes were built adjacent to the area of the site containing the waste pits. The waste created odors and seeped into the soil and groundwater, creating a hazard for the neighbors. In 1983, EPA added the site to its list of sites needing cleanup, the National Priorities List (NPL).

Local officials and stakeholders celebrate opening day in Fullerton California

The site consisted of two distinct areas: the Ramparts area, which is in the eastern portion of the site and surrounded by developed property and residences; and the Los Coyotes area, which is in the south-western portion and once had a portion of the Los Coyotes Country Club Golf Course overlying it (holes 6, 7, and 8). The site is adjacent to the golf course to the south and a regional park to the west. The Ramparts and Los Coyotes Areas each contained 6 waste sumps with depths up to 55 feet. The waste sumps contain approximately 97,100 cubic yards of contaminated material (72,600 cubic yards of solid waste and 24,500 cubic yards of contaminated soil). The waste was primarily an acidic sludge waste generated during the refining process for high octane aviation fuel. Drilling muds were placed over a few of the Ramparts sumps in the early 1950s.

The Los Coyotes area was covered with soil in 1960 to build part of Los Coyotes Golf Course. In the 1960s and 1970s, homes were built in the area. Subsequently, complaints about odors and health problems from residents near the site led to investigations by local, state, and Federal agencies. In 1983, the Ramparts area was covered by a temporary liner. However, tar-like waste continued to seep to the surface of the dirt cap. Access to the site was restricted by a fence and a security guard. At the time most of the remediation work was done, in the mid-1990s, more than 6,700 people lived within 3 miles of the site. The distance from the site to the nearest residence is less than 100 feet.

Tar-like substances seeped out of the ground in the early 1980s

Remedy and Reuse:

The remedy, built between 1996 and 1998, consisted of the following elements: (a) subsurface barrier walls were built around the pits; (b) a multi-layered cap was placed over the pits; (c) a network of piping was installed under the cover to collect gases, which are then routed to a carbon treatment plant; and (d) equipment was installed to monitor the groundwater in the area. During the construction of the remedy, efforts were made to protect nearby residences from disruption and runoff from the site. These included protective fencing, sandbags, and site work.

The site is now used as a portion of the adjacent golf course. Some of its acreage is newly added to the course, and some was already being used by the golf course prior to the remediation. In addition to the familiar golf-course features, such as fairways, greens, and trees, the design of the course incorporates the requirement to direct rainwater away from the old pit areas and into specified drainage paths. This design is intended to prevent water from pooling over the pits. Monitoring includes inspections of the entire site on a regular schedule and after major rainfalls, and periodic sampling of the groundwater.

At the McColl site, designers included landscaped areas as part of a golf course built over a cover system. Designers omitted a layer of cobbles for covers over landscaped areas to minimize settlement caused by the weight of the cap.

The site is operated by the Los Coyotes Country Club through agreements among the McColl Site Group Oil Companies, McAauley LCX Corporation, which owns the country club, and EPA. The agreements call for the country club to perform the routine inspection in the course of its management of the golf course. Additional inspections, operations and maintenance will be performed by contractors working for the McColl Site Group Oil Companies, and EPA will continue to oversee the work.

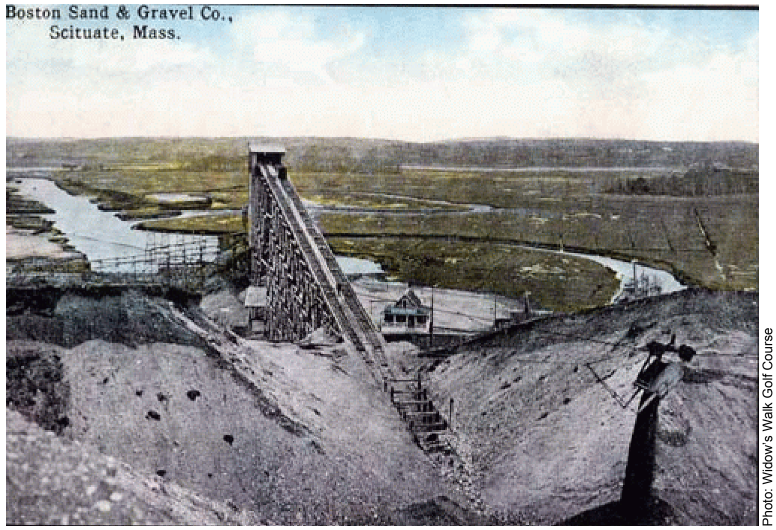
Lessons:

- Careful planning and cooperation with the local community and nearby golf course owner were essential to the acceptance of the remedy and reuse plans.
- It is feasible to develop a golf facility, even if a containment system does not have a bottom liner, so long as the appropriate engineering controls are used to protect people and the environment from potential contamination.
- Creative engineering based on knowledge of the existing waste deposits and hydrogeology can lead to useful remedy and reuse designs.
- Golf reuse can be compatible with groundwater and gas collection and treatment systems.

Widow's Walk Golf Course, Scituate, Massachusetts [5]

Site History:

This 120-acre site had been a sand and gravel quarry. After it was mined out it became an illegal dumping ground and a very impoverished habitat for wildlife. The site had several high ridges and mining spoil piles that offered scenic views of the Atlantic Ocean, Cape Cod Bay, and the tidal North River.



The golf course was built on an abandoned gravel quarry that had been scared by many years of gravel mining

Remedy and Reuse:

In addition to allowing for golf play, this course is designed to demonstrate that a variety of habitats can be integrated with and thrive within or alongside a golf facility. The golf facility includes a corridor of mixed habitats such as ponds, wetlands, vegetated streams, wooded areas, open grassy areas, vernal pools, and other habitats, to support a great variety of plants and animals. It was planned, built and operated with the guidance of various environmental experts who evaluated wetland and habitat issues, planned land reclamation efforts, and developed an approach to protect a town water supply. All these activities were undertaken while ensuring that the site remained accessible and affordable for public golf.

The first step in the project was to assemble a team of environmental experts to assess and map the site for environmental resource areas such as endangered plants and animals, regulated lands, and serious environmental threats. Then, the golf course architects developed a golf course layout that was designed to avoid all of the identified resource areas. Since these areas of special concern took up over 50 percent of the site, avoidance was impossible. A compromise was reached to establish priorities for the environmental resource areas and balance the needs of the golf course with those of the habitat areas.

Special Golf Course Features:

Protecting Drinking Water Supplies. Because a town drinking water well was located in the center of the very sandy site, groundwater protection was paramount. Zones of contribution were established around the well, corresponding to varying degrees of permissible impact. Zone I allowed absolutely no fertilization or pesticide of any kind, and included monitoring wells to

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[5] Love, Bill. 1999. *An Environmental Approach to Golf Course Development.* American Society of Golf Course Architects, and Widows Walk Golf Course web site. http://www.widowswalkgolf.com/home.asp?courseid=57

ensure this protection. Zone II allowed reduced levels of fertilizers and pesticides and included water quality monitoring. Zone III, outside the well recharge areas, was unregulated.

Golf Course Irrigation. Water for irrigating the golf course came from reopened and previously abandoned drinking water wells that no longer met EPA purity standards. The water quality was sufficient for irrigating the golf course turfgrass. In addition, when applied to the turf, the irrigation water became sufficiently filtered to become an acceptable contributor to the town well. In essence, the golf course became a bio-filter to improve the quality of the groundwater.

Fertilizer, Pesticide, and Water use. A key goal of the development team was to use only 50 percent of the water, fertilizer, pesticide, and fossil fuel required at other golf courses in the area. To reach this goal, the developer selected drought and disease resistant grasses that require little fertilizer. The golf course has met those reduced input goals, but only with the understanding and support of golfers who do not demand lush green turfgrass all year long. The golf course turns more brown than green during drought years, but still provides an exciting round of golf.

Recycling. During construction, efforts were made to recycle on-site materials and minimize water use. Wood chips and sawdust were made into compost to compensate for the lack of topsoil, ground up asphalt debris was used for cart paths, and carpet scraps were used to fabricate bunker faces. Meters for measuring water use, soil moisture, and temperature were also installed.

Photo: Widow's Walk Golf Course

Widow's Walk is a municipally owned 18-hole layout adjacent to the historic North River and within sight of the Atlantic Ocean.

Ecosystem Research. After the course was opened, the management team worked closely with universities to encourage research on the facility, and with the Massachusetts Audubon Society to better manage habitat areas. Both activities are continuing with great success. Several research projects have been started, many habitat areas have been given nesting supplies, and more than 75 species of birds have been sighted on the golf course.

Education. A golfer guidebook was written to inform golfers about the wildlife value of each hole and the special management practices used. Each sale of the book produces a dollar for the golf course and a dollar for the Massachusetts Audubon Society.

Widow's Walk, designed, built, and maintained under the watchful eyes of experts in golf and the environment, provides valuable habitats for plants and animals, environmental educational and research opportunities, and a pleasant golfing area.

Lessons:

- Golf courses can be compatible with habitat enhancement areas.
- Drought- and disease-resistant grasses that require fewer chemicals are available for golf course use.
- On-site materials can be used to reduce costs and ecological impacts of golf course construction and maintenance.

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Appendix A. Information Sources for Golf Facility Development

American Society of Golf Course Architects
221 North LaSalle Street
Chicago, IL 60601
312-372-7090
http://www.golfdesign.org/

Audubon International
Headquarters
46 Rarick Road
Selkirk, NY 12158
518-767-9051
http://www.audubonintl.org/

Center for Resource Management
500 East 8th Avenue, Suite 100
Denver, CO 80203
303-832-6855

1104 East Ashton Avenue, Suite 210
Salt Lake City, UT 84106
801-466-3600
http://www.crm.org/index.html

Environmental Engineering Consultants
(See local listings.)

Golf Course Builders Association of America
Executive Office
727 "O" Street
Lincoln, NE 68508
402-476-4444
http://www.gcbaa.org/

Golf Course Superintendents Association of America
1421 Research Park Drive
Lawrence, KS 66049-3859
800-472-7878 or 785-841-2240
http://www.gcsaa.org/

National Golf Course Owners Association
1470 Ben Sawyer Boulevard, Suite 18
Mount Pleasant, SC 29464
800-933-4262 or 843-881-9956
http://www.ngcoa.org/

National Golf Foundation
1150 South US Highway One, Suite 401
Jupiter, FL 33477
561-744-6006
http://www.ngf.org/

United States Golf Association
PO Box 708
Far Hills, NJ 07931
908-234-2300
http://www.usga.org/

United States Environmental Protection Agency
Headquarters
Ariel Rios Building
1200 Pennsylvania Avenue, N.W.
Washington, DC 20460
202-260-2090
http://www.epa.gov/

Appendix B. Superfund Golf Facility Reuse Sites and EPA Contacts

Site Name and Location	Reuse	Primary Contaminants	Remedial Activities	EPA Contact
Anaconda Company Smelter Anaconda, MT	Golf course	Arsenic, metals including copper, cadmium, lead, and zinc	• Relocated residents • Removal of contaminated soil and placement of clean soil	Charles Coleman 406-296-7813 coleman.charles@epa.gov
Kane and Lombard Streets Drum Baltimore, MD	Golf driving range	VOCs and metals including cadmium, lead, magnesium, and nickel	• Constructed a surface barrier wall • Constructed a geosynthetic cap	Chris Corbett 215-814-3220 corbett.chris@epa.gov
Lexington County Landfill Cayce, SC	Golf driving range and putt-putt	Benzene, bis(2-ethylhexyl) phthalat.e, bromodichloromethane, and chlorobenzene	• Consolidation and capping the waste piles with clay and soil • Control the venting of the methane gas	Terry Tanner 404-562-8797 tanner.terry@epa.gov
McColl Fullerton, CA	Golf course	Sulfur dioxide, VOCs, SVOCs, and metals	• Removal of wastes • Temporary caps placed	David Seter 415-972-3250 seter.david@epa.gov
Mill Creek Dump Erie, PA	Golf course	Polycyclic aromatic hydrocarbons, PCBs, and heavy metals	• Removal of material • Soil cap • Flood retention basin	Romuald A. Roman 215-814-3212 roman.romuald@epa.gov
PAB Oil and Chemical Services, Inc. Abbeville, LA	Golf driving range	Arsenic, barium, chromium, lead, manganese, and acetone	• Remove top layer of soil • Install a clay cap	Ursula Lennox 214-665-6743 lennox.ursula@epa.gov
South Weymouth Naval Air Station (SWNAS) Weymouth, MA	Golf course, recreational, and open space	Battery acid, lead, VOCs, and heavy metals	• Removal of drums and containers • Removal of soil • Place soil cap on surface	Patty Whittemore 617-918-1382 whittemore.patty@epa.gov
Stauffer Chemical Tarpon Springs, FL	Golf course	Phosphorous, arsenic, radium-226, berylium, and heavy metals	• Removal of hazardous material and soil • Consolidation and capping of the site • Establish land use ordinances • Construct physical barriers	Nestor Young 404-562-8812 young.nestor@epa.gov

Appendix C. Acronyms

AASHTO	American Association of State Highway and Transportation Official
BMP	Best Management Practice
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CFR	Code of Federal Regulations
CWA	Clean Water Act
EPA	U. S. Environmental Protection Agency
FS	Feasibility Study
FWPCA	Federal Water Pollution Control Act
HAZWOPER	Hazardous Waste Operations and Emergency Response
HRS	Hazard Ranking System
IPM	Integrated Pest Management
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NEWS	National Weather Service
O&M	Operation and Maintenance
OSHA	Occupational Safety and Health Administration
PA	Preliminary Assessment
PPA	Prospective Purchaser Agreement
PRB	Permeable Reactive Barriers
PRP	Potentially Responsible Party
RA	Remedial Action
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RI	Remedial Investigation
ROD	Record of Decision
RPM	Remedial Project Manager
SARA	Superfund Amendments and Reauthorization Act of 1986
SI	Site Inspection
S/S	Solidification and Stabilization
SVOC	Semi-Volatile Organic Compound
USGS	U.S. Geological Survey
USWB	U.S. Weather Bureau
VOC	Volatile Organic Compound